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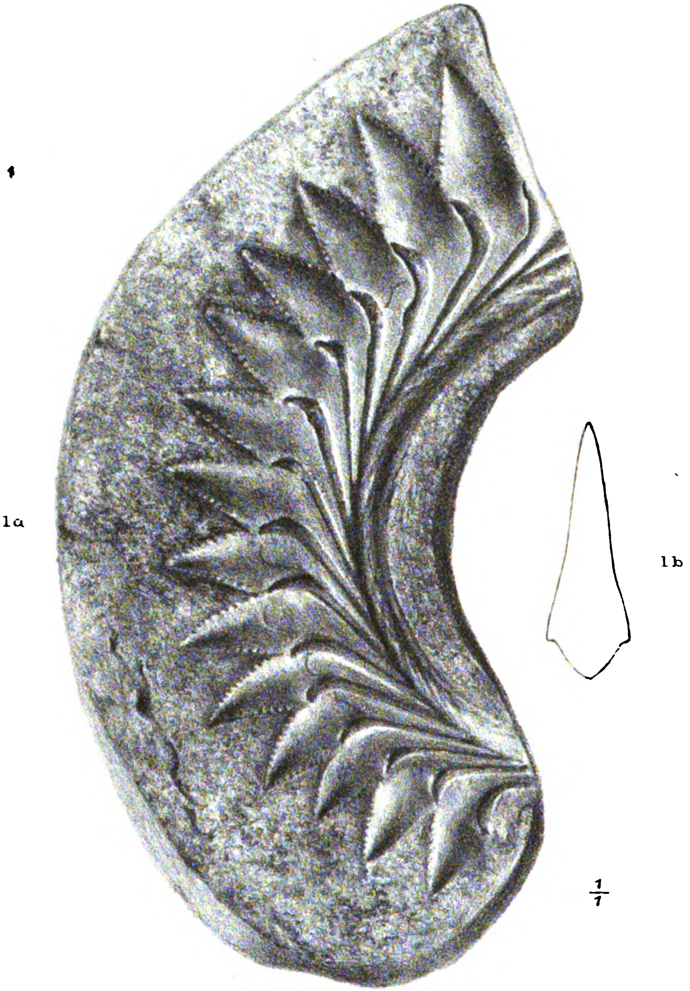

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Carboniferous: *Western Australia.*

THE
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NEW SERIES. DECADE III. VOL. III.

No. I.—JANUARY, 1886.

ORIGINAL ARTICLES.

I.—On a Remarkable Ichthyodorulite from the Carboniferous Series, Gascoyne, Western Australia.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc.

(PLATE I.)

TWO years ago, Mr. Robert H. Scott, F.R.S., Secretary to the Council of the Meteorological Office, kindly sent me a letter from the Rev. J. G. Nicolay of Fremantle, Western Australia, accompanied by a photograph of a fossil, the original of which had been found by Mr. Davis "in the valley of the Arthur River, an affluent of the Gascoyne."[1]

I readily identified the fossil photographed as the impression of a fish-spine, similar in form, but more highly curved than those discovered in the Coal-measures of Arkansas, Indiana and Illinois, originally described by Prof. Leidy as a fish-jaw, and named by him *Edestus vorax* in 1855, and later as a fish-spine by MM. Newberry and Worthen (Geological Survey of Illinois, 1870, vol. iv. pp. 350–353, pl. i.). Having expressed a wish to see the fossil itself, Mr. Scott at once wrote to his sister, Lady Barker, wife of the Governor of Western Australia, at Perth, who most kindly interested herself to obtain the loan of it from Mr. Nicolay. After a protracted correspondence, Mr. Edward T. Hardman, F.G.S., of the Government Geological Survey of Ireland (who was at that time engaged upon a Survey of the Kimberley District, Western Australia), was, upon his return to England, entrusted with the charge of this unique specimen, which is now in my hands.

The fossil (which is represented in our Plate I. of the natural size) consists of the half of a heavy clay-ironstone nodule, having the intaglio impression of a curved organism; the relievo half of the nodule was not found. It was picked up by Mr. Davis "in the valley of the Arthur River, an affluent of the Gascoyne from the right, *i.e.* the north, above the confluence of the Lyons with the Gascoyne, and about 130 miles in direct distance from the sea; both rivers have, as I am informed, cut their channels through a flat-topped range, which stretches beyond the Lyons to the north-west, and on the top of which are found fossils very numerous, bedded in limestone, among which a striated-winged Spirifer" (probably *Spirifer vespertilio*, G. Sby.?) "is prominent. It may be assumed that the limestone bed is superior in position to that of the ferruginous concretionary sandstone" (clay-ironstone) "in which the fossil was bedded" (extract from Rev. J. G. Nicolay's letter to Lady Barker, Government House, Perth, W.A., 13th July, 1883.)

---

[1] Spelt, in some maps, "Gascoigne."

A carefully-prepared cast from the natural mould of the fossil shows us in relief the curved outline of what may be estimated as about three-fourths of the entire spine of a fish closely related to *Edestus Heinrichsii*, of Newberry and Worthen, from the Coal-measures of Belleville, Illinois, but of much smaller dimensions, less robust, and more highly curved than the American species.

We see in the Australian fossil 14 perfect flattened lancet-shaped denticles, the cutting edges of which are crenulated along each border (like the teeth of many of the Plagiostomous fishes) the denticles being closely set along the outer curve of the spine, and touching each other at their broadest expansion. They increase gradually in size from one extremity of the fossil to the other. The smallest denticle measures 3 lines in breadth, and 7 lines in length; the largest is 5 lines broad, and 11 lines in height. There is evidence of the bases of one more denticle at the smallest end, and two more at the largest end of the spine. The outer curve (which forms the segment of a nearly true circle of 4½in. diameter) measures around the points of the denticles 6¾in., and on the inner margin of the spine (following the curve in each case) 3¼ in. The breadth of the spine with its denticle at the broadest end is 16 lines; and at the narrowest end 11 lines. The character of the American *Edestus* is that the shaft of the spine is segmented throughout, and breaks up into curved portions, each bearing a denticle; these segments overlap to such a degree that the bases of the denticles are seen to curve beneath each other, forming a series of raised imbricated ridges on the sides of the spine, each curved ridge leading up to the base of a denticle, as admirably shown by Prof. Leidy in his original paper. The substance of the shaft of the spine of the Australian fossil must have been much less massive than the American form, but was evidently, like it, highly enamelled along its outer convex toothed border, the hollows of the cast being all finely glazed.

In the Proceedings Acad. Nat. Sci. of Philadelphia, vol. vii. Oct. 30, 1855, p. 414, Dr. Joseph Leidy gives the name *Edestus vorax*, to a new genus of fishes, founded on a supposed fragment of a jaw with portions of four teeth. In the Journal of the Acad. Sci. of Philadelphia, Nov., 1856, 2nd ser. vol. iii. p. 159, Dr. Leidy describes the specimen more fully, and figures it on plate xv. "The fragment of jaw is six inches in length; and it measures three inches in depth from the dental border. The sides are symmetrical, and slope divergently from the latter position towards the base, which is convex and moderately keeled in the median line. At the dental border the jaw is about seven-eighths of an inch in thickness, and at the thickest part of its base measures one inch and four-fifths. Longitudinally the base of the jaw is slightly concave and furrowed. The surface of the bone is covered with fine vermicular, reticulating, broken ridges, assuming a striking resemblance to Arabic writing. The most remarkable peculiarity of the jaw is its segmented character; and of the segments the fossil retains two very nearly perfect ones with portions of two others. Each segment in outline forms an irregular pentahedron; and each possesses a single coössified tooth, whose broad surfaces abruptly increase the acclivity of the sides of the jaw."

This specimen is most probably from the Carboniferous series, and was found at Frozen Rock, Arkansas River, 20 miles below Fort Gibson, in the Indian Territory.

Prof. J. S. Newberry describes a much smaller specimen, under the name of *Edestus minor*, in the Geol. Surv. of Illinois, vol. ii. 1866, p. 84, and gives a figure on plate iv. fig. 24. This figure represents one tooth only, 10 lines long, and 5½ lines wide at base, and 3 lines thick, set saddle-like upon the edge of a flat, bony jaw. This specimen was obtained from the Coal Measures, Posey County, Indiana. In vol. iv. of the same work, at p. 350, Newberry and Worthen describe and figure, pl. i. fig. 1*a*, 1*b*, another specimen under the name of *Edestus Heinrichsii*, from the Coal Measures of Belleville, Illinois. The following is the description given by Messrs. Newberry and Worthen of *Edestus Heinrichsii*, N. & W., 1870:[1]—"Spine robust, one foot or more in length, by two and a half inches wide, and one and a quarter inch thick, composed of dense, bony tissue, symmetrically flattened, with an ovoid section below; lenticular above; one margin nearly straight, the other gently arched; the basal end irregularly rounded off; the arched border set with nine large, triangular, flattened, doubly crenulated, enamelled denticles, each about an inch in height, the upper half of the straight line forming a sharp cutting edge. The denticles of the arched border are broadly triangular in outline, rising perpendicularly from the curved edge on which they rest, each three-quarters of an inch in height, by one and a quarter inch in breadth, compressed laterally, with crenulated cutting edges. They are contiguously placed, and each is embraced by the acute

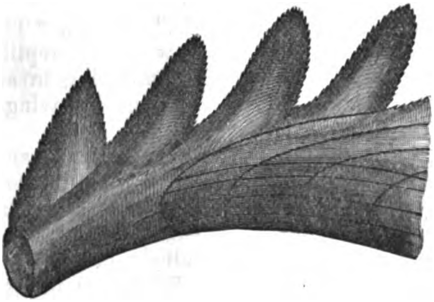

FIG. 1.—Part of the spine of *Edestus* sp? (*E. Heinrichsii*?), Coal M., Indiana.

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[1] Geological Survey of Illinois, vol. iv. Geology and Palæontology, 4to, Illinois, 1870, pp. 350–353, pl. i. figs. 1*a* and 1*b*. Some confusion exists in the references to the figures here; for of the two species drawn on the plate, the one named *E. Heinrichsii* agrees best with Leidy's original figure; whilst the one named *E. vorax*, which agrees with our woodcut (*supra*), has much larger denticles.

prolongations of the enamelled base of the superior denticle, which reaches back to its middle point. The spine is segmented throughout, each segment bearing a denticle; the segments overlapping to such a degree that the one bearing the superior denticle reaches two-thirds of the distance from the summit to the base of the spine."

A comparison of the Australian fossil spine with the American species of *Edestus* (excellent casts of both of which are in the British Museum, Natural History) has convinced me that its true place is in or near to Leidy's genus. The denticles are placed on the *convex* edge of the spine, a peculiar feature in the genus *Edestus*, nearly all the spines of fossil plagiostomous fishes being denticulated along the inner *concave* curved edge.[1] The imbricated curved lines passing from each denticle obliquely across the shaft of the spine are also seen in both, and are quite peculiar to *Edestus*.

Prof. Newberry has clearly pointed out the objections to the theory, at first suggested by Prof. Leidy, that *Edestus* was part of the mandible of a plagiostomous fish. He mentions that "the jaws of sharks are always cartilaginous, holding the bony and enamelled teeth only by ligamentous attachments, so that in a fossil state the jaws have usually disappeared, and the teeth are scattered, whereas in *Edestus* we have a dense bone to which the tooth-like denticles are united by a firm bony anchylosis." Again, "The form of the fossil is wholly unlike that of any jaw of fish, reptile, or mammal known, being rounded below, and terminating in an acute point, smooth, even polished, and evidently never having been covered by integument."

In comparing the Australian fossil with various specimens in the collection, Mr. William Davies drew my attention to the similarity in arrangement of the teeth of *Janassa bituminosa*, from the Permian of Durham; in one specimen of which six teeth with prolonged and highly-curved bases may be seen united; but these teeth differ in arrangement from the denticles of *Edestus* in being placed broadwise behind each other, not edge-to-edge in a row, as in *Edestus*.

The only structure amongst fossil fishes strikingly analogous to *Edestus* is to be found in the pectoral fins of the genus named by Agassiz *Ptychodus*, from the Chalk of Sussex, and since described by Prof. E. D. Cope from the Chalk of Kansas, under the name of *Pelecopterus*.

Professor Cope writes:—"The entire pectoral fin, so far as is known, is devoted to the construction of a powerful spine. This follows from the fact that the spine is supported by all the basilar bones. Six of the latter articulate in the fossæ of the groove of the scapula. They are flat, contracted at the middle, and expanded at the extremities. In front of these are two others of a short, thick, cylindric form, one applied to the superior, the other to the inferior facets of the scapula above mentioned, while the tuberosity rises pedestal-like between them. This structure gives a slight hinge-movement like the opening of the blade of a knife, and entirely unlike the rotary hinge-movement characteristic of the pectoral spines of Siluroid fishes."

---

[1] In *Pleuracanthus* the spines are barbed on *both edges*, and so also are the spines of the Sting-rays.

"The spine is composed of parallel rods in close apposition. The anterior edge being oblique, the extremities of the rods terminate successively at the border, which is trenchant, constituting the offensive part of the spine. The edge is hardened, and the adjacent parts of the spine thickened, and in some cases roughened by a deposit of a hard substance resembling enamel. It is either straight or regularly undulate or serrate, with recurved, acute, tooth-like processes. The smaller species exhibit the serrate character, the larger the regular border. In either case a most formidable weapon is indicated, not less admirable than those already described from Palæozoic rocks. *There is a considerable resemblance between the serrate type and the spines of the Carboniferous genus Edestus,* in which the teeth are more developed and denticulate." (E. D. Cope. Report of the United States Geological Survey of the Territories. F. V. Hayden, U.S. Geologist-in-charge, vol. ii. p. 244B. 4to. Washington, 1875.) (See Woodcut, *infra*, Fig. 4.)

Fig. 2.

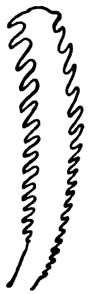

Fig. 3.

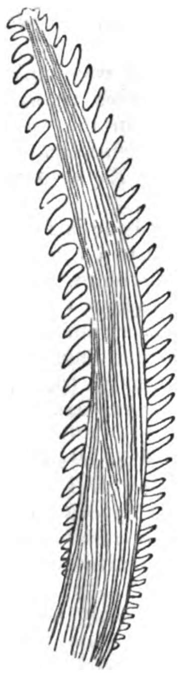

Fig. 4.

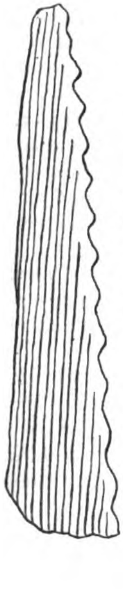

Fig. 5.

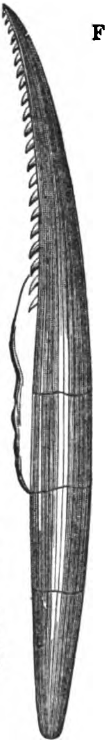

Fig. 2. Pectoral Spine of *Aspredo lævis*; (recent) *Surinam.*
" 3. " " *Doras*, sp. " S. America.
" 4. " " *Pelecopterus*, sp.. Chalk, Sussex.
" 5. Dorsal Spine of *Hybodus*, Wealden, Sussex.

Amongst recent plagiostomous fishes I do not find any one species with spines at all comparable in the least degree with the type of *Edestus*. If it be permissible to interpret the Australian fossil to be the impression of the spine of the pectoral fin of an *Edestus*-like fish, there are numerous examples of living Siluroid fishes with powerful pectoral fin-spines, some of which at least have denticles upon the outer as well as the inner edge of the spine, although none are so highly curved as the Gascoyne fossil. *Arius rita*, of the river Ganges, has denticles on *both edges* of its pectoral spines; so also has *Aspredo lævis* (Woodcut, p. 5, Fig. 2), from Surinam; *Synodontis omias*, and *Auchenaspis falcarius*, from West Africa; *Arius falcarius*, Formosa; and *Silurus glanis*, from Lake Derkos; *Doras*, sp., from South America (Woodcut, p. 5, Fig. 3), and many others.

It is difficult to imagine any fish with a pectoral spine curved to so great a degree as is this Australian ichthyodorulite, but on the other hand it seems improbable that it was a median dorsal defence.

To quote again from Prof. Newberry:—"The segmented structure of the fossil is its most marked and anomalous feature, but one equally so, whether it be considered spine or jaw, and for which no parallel suggests itself. It is undoubtedly to this structure that we must ascribe the absence of a large medullary cavity, as each segment seems to have been nourished somewhat independently of its fellows.

"It is also evident that this spine was implanted in the integument at a low angle, and that an investing skin or other nutrient tissue covered fully half its surface, on the lower portion reaching up to the enamelled bases of the denticles. This is the relative position of the defensive spines of Rays, to which an analogy is suggested by this character.

"In some plagiostomous fishes, a bone is found quite buried in the integuments of the back, and which is a rudimentary representative of a posterior dorsal fin; it is, therefore, not impossible that we have in the fossil before us, a higher development and special modification of that organ." (Newberry and Worthen, *op. cit.* p. 352.)

Referring again to the valuable and suggestive memoir by Prof. E. D. Cope on *Pelecopterus* quoted above (p. 4), I cannot but think that it affords the most probable explanation of the anomalous structure in *Edestus*.

"The entire pectoral fin," says Cope, "so far as it is known, is devoted to the construction of a powerful spine." "The spine is composed of parallel rods in close apposition. The anterior edge, being oblique, the extremities of the rods terminate successively at the border, which is trenchant, constituting the offensive part of the spine."

It appears to me to be only necessary that the 'parallel rods' composing the spine of *Pelecopterus* should be bent into curves, corresponding to the segmentation seen in *Edestus*, and we at once have a solution of the peculiar structure in the latter.

If this interpretation be accepted, then *Edestus* must be deemed to be, like *Pelecopterus*, a modified pectoral fin-spine, composed of a number of parallel rods in close apposition, but highly curved in the former; the anterior edge in both being oblique, the extremities of the rods terminate at the border, constituting with its dentated edge the offensive part of the spine.

Without attempting more on the present occasion than to point out the interesting analogy between the Australian fossil and the American genus *Edestus*, it seems, nevertheless, of the greatest interest to call attention to the probable nature of this organism and its geological age.

So lately as June 6th, 1883, Mr. W. H. Hudleston, F.R.S., F.G.S., communicated a paper to the Geological Society of London, "On a Collection of Fossils and of Rock-Specimens from West Australia, north of the Gascoyne River," since published in the Quart. Journ. Geol. Soc. vol. xxxix. pp. 582–595, pl. xxiii.

In this paper Mr. Hudleston mentions an earlier paper by Mr. F. T. Gregory in 1861, and a map and sections presented to the Society in 1847. "The paper and sections by Mr. Gregory must be regarded (says Mr. Hudleston) as having laid the foundation of Western Australian Geology south of the parallel of the Gascoyne river." "Mr. Forrest, the Colonial Surveyor, appears to have discovered a range, or more properly a sort of continuous outcrop trending N.N.W. for nearly 150 miles, which has yielded an interesting suite of Carboniferous fossils." A list of about 32 species is given by Mr. Hudleston, namely, 5 Corals, 2 Echinodermata, 4 Polyzoa, 8 Brachiopoda, and 2 Lamellibranchiata. It is not without interest in connection with the present discovery of a Fish-spine in this region closely related to the American *Edestus* of Leidy, that two species of *Evactinopora* are described, one of which is said to be similar to Meek and Worthen's *Evactinopora grandis* and is also, like *Edestus*, from the Carboniferous of Illinois (see Hudleston, *op. cit.*).

I have been requested to append the discoverer's name to this fossil, and as I am unwilling, in the present state of our knowledge, to make a new genus for its reception, I propose to name it *Edestus Davisii.*

EXPLANATION OF PLATE I.

Fig. 1*a*. Pectoral fin? spine of *Edestus Davisii*, H. Woodw. (nat. size), from the Carboniferous Series of the Gascoyne District, Western Australia.

1*b*. Conjectural outline section of spine.

II.—Irish Metamorphic Rocks.

By G. H. Kinahan, M.R.I.A., etc.

Read at British Association, Aberdeen, 1885.

THE meeting of the British Association in Montreal gave different Irish geologists facilities for examining the Archæan rocks of Canada and the States, while since then they and also American geologists have had opportunities for studying the Irish Metamorphic rocks; it may therefore be allowable to give an epitome of our knowledge in regard to the latter.

In ten localities in Ireland are found metamorphic rocks more or less similar to those of America; these localities may be classified as follows:—1st, Boylagh and Kilmacrenan, Co. Donegal; 2nd, Tirhugh, Co. Donegal; 3rd, Erris, Co. Mayo; 4th, Slievegamp and Ox Mountain, Cos. Mayo, Sligo, and Leitrim; 5th, Charlestown district, Co. Mayo; 6th, Slievegallion or Pomeroy district, Cos. Tyrone and Derry; 7th, Cary or Ballycastle district, Co. Antrim; 8th, Yar-Connaught or West Galway; 9th, Croaghankinshella, Cos. Wicklow and Wexford; and 10th, Carnsore, Co. Wexford.

Boylagh and *Kilmacrenan.*—These are the northern baronies in the county of Donegal, across which obliquely a tract of granitic rocks extends, having outlying patches in Rossgull and Fanad, in the latter barony. In connection with the gneiss there are some remarkable peculiarities which as yet have not been explained; but as the country has still to be completely explored, it seems expedient only to say that the Americans seem to consider the gneiss and associated schists of Lackagh valley to be lithologically identical with the American rocks of Mt. Alban series (Hitchcock) or Hudson River series (Dana), as seen in the vale of the Schuyllkill river, Pennsylvania; and these American rocks they consider to be the equivalents of the English Ordovician or Lower Silurian. Immediately south of the gneissoid rocks supposed to be Laurentians, there is a long tract of rocks which lithologically are identical with some of the Ontario Laurentians, much more so than any of the gneissose rocks; they, however, have been ignored. To the main tract of gneiss in the barony of Kilmacreenan, *in any place*, either along the north-west or south-east of its limits, there are no hard boundaries to indicate an unconformability or fault boundary, as along these boundaries *the gneiss graduates into schists, and the latter into submetamorphic rocks;* to the south-east, however, the graduation is, in general, more rapid than to the north-west.

Tirhugh.—This tract is situated to the N.W. of Pettigo, in the south portion of the Co. Donegal. The rocks partake very much of the lithological characters of some of the Ontario Huronians and Laurentians, but up to the present time they have not been claimed as Irish Laurentians. In former writings I have suggested that they are probably the representatives, either of the Passage beds between the Ordovicians and the Cambrian, or of the Upper Cambrians.

Erris.—This is a portion of North-west Mayo. The gneissose rocks have no well-defined boundaries; neither has there been found in connection with them an overlying unconformable conglomerate, as has been believed by some, on account of the wording of their published descriptions. In former papers (Royal Geol. Soc. Ireland) I have suggested that these rocks are metamorphosed Cambrians, but no positive statement can be made as to their age; lithologically they are similar to the metamorphosed Cambrians of the Co. Wexford, but they are also very like some of the American Laurentians.

Slieve Gamp and Ox Mountains.—These rocks occupy a long narrow strip which extends from north-east Mayo, across Sligo into the county of Leitrim. Some of the rocks are peculiar, as they occur, similarly to the Norians of the Province of Quebec, as intrusive masses, into which a coarse foliation has been subsequently introduced. The assemblage appears to be the north-easterly extension of the rocks of West Galway; elsewhere I have suggested that they are probably either metamorphosed Ordovicians or Upper Cambrians.

Charlestown District.—This small exposure occurs near the north-east boundary of Mayo; the rocks are more or less similar to those in Tirhugh, but so few of them are exposed that it is difficult to form an opinion as to their age; for the reasons given in a paper read before the Royal Irish Academy, I have suggested that they may be either of Upper Cambrian or Ordovician age, probably the latter. As yet they have not been claimed as Laurentians.

Slieve Gallion or Pomeroy District.—This area is principally in the Co. Tyrone, only a small portion extending into the Co. Derry. The opinions in regard to the age of the rocks have undergone sudden and extraordinary changes. First, they were mapped as of Lower Silurian age, and when I showed that this classification must be incorrect, it was again insisted on; but subsequently this opinion was suddenly ignored, and they were stated to be of Laurentian age. Lithologically many of these rocks are very similar to some of the Canadian Huronians, and if there are any Archæan rocks in Ireland, they probably occur here, as the rocks are evidently much more ancient than the Ordovician to the south, while they appear to be older than the submetamorphic rocks to the northward in the Co. Derry; however, for reasons given elsewhere, I suspect that they are metamorphosed Cambrians.

Cary or Ballycastle District.—These rocks occupy a tract at the extreme north-east of Ireland, in the Co. Antrim. They seem to be the north-east extension of the Slievegallion rocks, and to be of a similar age, having been heaved northward by the great faults of the Lough Neagh basin. As yet they appear to have escaped the general confiscation.

Yar-Connaught or West Galway.—This tract lies immediately north of Galway Bay. The age of these rocks is very apparent, they rest on a great anticlinal curve, the axis of which dips westward, thus bringing up the oldest rocks to the westward, in the hill group called Bennabeola. Some of the older rocks are lithologically identical with the Laurentians of the district of Chelsea, Province of Quebec. Yet these older rocks of Bennabeola have not been claimed as Laurentians, although the younger rocks to the southward have been — although the latter, from their fossils in the unaltered portions, appear to be the equivalents of the English Llandeilo and Bala series.

Croaghankinshella.—Here the highly altered rocks occupy a small tract at the meeting of the counties of Wicklow and Wexford, and if lithological characters are conclusive, they ought to be included among the Irish Laurentians, which up to the present has not been done. Northward they have a hard boundary; southward their margin is obscured by superficial accumulations, but eastward and westward they graduate into the rocks belonging to the upper divisions of the Irish Ordovicians.

Carnsore.—This is a small tract at the S.W. extremity of Ireland, in the Co. Wexford. The rocks therein have not been claimed as Laurentians by Dr. Hull, although some have been so classed by Dr. Callaway. All the rocks are evidently portions of one group. To me it would appear that unquestionably they belong to the neighbouring rocks, which by their fossils are proved to be of Cambrian age.

The sole evidence for the existence of Laurentian rocks in Ireland is the lithological characters of the rocks; and if such characters are of value, they ought to be of equal value in every case. This, however, is not the case, as in many places rocks lithologically more or less similar to the American Laurentians are left out in the cold; while in other places younger rocks, whose age is indicated by their fossils, are included.

III.—THE TUFFEAU DE CIPLY SHOWN TO BE CHIEFLY OF TERTIARY AGE.

By MM. A. RUTOT and E. VAN DEN BROECK.

WE wish briefly to state an important result, which the study of certain Tertiary and Cretaceous beds in the neighbourhood of Mons has enabled us to arrive at.

For a long time past, the beds, well known in the district just mentioned, by the name of *Tuffeau de Ciply*, have been considered by all geologists to be the equivalents of the Maestrichtien, that is to say, as belonging to the highest subdivision of the Cretaceous series of Belgium.

Now, our recent researches have convinced us that in the group of beds called the *Tuffeau de Ciply*, there have been confounded two series quite distinct from each other:

A. A lower fossiliferous series of slight thickness, extremely rich in characteristic Cretaceous species, amongst which may be mentioned specially *Thecidium papillatum* and *Belemnitella mucronata.* We propose to give to this inferior tuffeau, which appears to correspond to certain horizons of the Upper Cretaceous (Maestrichtien) of Limbourg, the name of *Tuffeau de St. Symphorien*, from the locality where it may, at present, be best observed.

B. An upper series, with fossiliferous zones, devoid of Cretaceous species,[1] but containing, on the contrary, a fauna with a Tertiary facies, including numerous forms identical with those of the *Calcaire grossier de Mons.* This series, which attains a thickness of nearly twelve metres, constitutes the type of the deposit known by the name of *Tuffeau de Ciply.* Its base is formed by a conglomerate called the *Poudingue de la Malogne*, which, in certain localities, contains numerous rolled Cretaceous forms derived from the underlying formations.

The preceding data have been derived from stratigraphical and palæontological observations, which show, furthermore, that there exists an insensible passage between the Eocene formation known as the *Calcaire grossier de Mons* and the *Tuffeau de Ciply*, by the intervention of a deposit called the *Calcaire de Cuesmes à grands Cerithes.* On the other hand, a well-marked separation exists between the *Tuffeau de Ciply* and the underlying Cretaceous tuffeau with *Thecidium papillatum.*

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[1] Nevertheless, two Maestrichtian forms, *Thecidium longirostre*, Bosq., and *Argiope microscopica*, Schloth., have passed up into the Eocene *Tuffeau de Ciply*.

Our palæontological proofs are founded on the presence of nearly a hundred species, for the most part casts or impressions, collected in the *Tuffeau de Ciply*, from its base upwards, among which species there exist only a very few Cretaceous fossils, and these rolled, evidently derived from the underlying beds, in contrast with a rich fauna having a Tertiary facies, consisting of Gasteropods, Lamellibranchs, Corals, etc., amongst which may be distinguished species either identical with those of the *Calcaire de Mons*, or nearly allied to them, associated with numerous forms probably new.

A general examination of the smaller organisms, such as Foraminifera, Polyzoa, etc., leads us to believe that their comparison with the microscopical fauna of the *Calcaire de Mons* will lead to conclusions similar to those which we have arrived at from a comparison of their molluscan fauna.

We intend shortly to publish, in the Bulletin du Musée d'histoire naturelle de Belgique, a Memoir setting forth in detail the results that we have now briefly stated, and which modify in an unexpected manner the stratigraphical position of the line of separation of the Cretaceous and Tertiary formations of Belgium.

IV.—On a Modern Ferruginous Conglomerate upon Ashby Wolds, Leicestershire.

By W. S. Gresley, F.G.S.

During the summer of 1885, in excavating for a small reservoir for colliery purposes at Moira, three miles west of Ashby-de-la Zouch, an interesting deposit of a kind of Limonite Iron-ore was met with, the following description of which may interest some of the readers of the Geological Magazine.

The bed occurred about five feet below the surface soil, near a small stream, at a place called "Hanging Hill" [see Geol. 1-inch Map, Quarter-Sheet No. 63, N.W.]. In thickness it hardly reached a foot, but its extent was not proved; it rested unconformably upon stiff blue clay of the Coal-measures, and was overlaid by yellowish clay, loam, sand, etc., unstratified, containing a few pebbles and other drifted matter; it was principally composed of nodules and fragments of nodules of earthy yellowish brown ironstone, of similarly formed pieces of very hard and compact light grey siliceous stone having a thin crust or shell of compact dark brown iron-ore, (probably gōthite), of sandy nodular masses largely composed of limonite; of fragments and small nodules of fossiliferous hard red hæmatite generally coated with a bright red skin which is often powdery; also specimens of compact brown iron ore having a yellow ochre coating, sometimes the compact red and yellow hæmatites are associated in the same sample, the latter variety appears to form a kind of shell to the red ore, though occasionally the two kinds exist in thin alternating bands. These hard hæmatite fragments are sometimes partially composed of quartz grains, and the concentric zones of oxidation seen upon the surface of the specimen run through the gritty parts just as they do through those devoid of the quartz grains. Other specimens observed should, I think, be termed iron-jasper rather than classed as hæmatite. The remainder of the included pebbles, etc., are chiefly those of quartzite and fine-grained hard sandstones and slaty rocks of yellow, brown, and green tints; also small fragments of coal. The size of the fragments in the deposit range from mere specks to say eight inches in length, and the whole mass is cemented together into a very hard and often compact rock by brown iron ore of a semicrystalline siliceous character. The bed is also fossiliferous, in that it contains bits of decayed vegetable detritus, amongst which well-preserved *nuts* (hazel-nuts) occur. These organic remains are not petrified, but only browned and blackened, just as we sometimes find *Lepidostrobi*, ferns, etc., occurring in a peculiar decayed and carbonised condition in certain beds of the Coal-measures.

In regard to the derivation of this conglomerate and the way in which it was probably formed, I may add that the nodular lumps of earthy iron-ore, as well as the harder limonite-crusted masses, were originally clay-ironstones, etc., of the neighbouring Coal-measures; that the fragments of hard hæmatite (which are 'burnishers') have been derived from the outcrop of the Permian breccias by which the western margin of the exposed Leicestershire Coal-field is partly overlaid [see GEOL. MAG. for 1885, p. 333], and that the quartz and other pebbles, etc., have come from the Bunter series, also found within a mile or so of the locality of this iron-ore gravel-bed. The nuts, twigs, etc., were of course buried during the deposition of the gravel, but the cementing iron-ore, which has acted chemically so much upon the mass (as evidenced by the staining of the pebbles and the alteration of the clay iron-stones and other fragments), I consider has been thrown down during a quiet period subsequent to the deposition of the stones, etc., and was most likely produced from chalybeate waters issuing from the Coal-measures close by the bed of gravel; the whole was subsequently covered over, and thus consolidation resulted.

It need scarcely be added, that the presence of hazel-nuts in the deposit proves it to be of quite recent date.

POSTSCRIPT.—The finding of a rusty iron nail of square section, in lengh 2¼ inches, which is thickly, though irregularly, encrusted with iron oxide and sandy matter, in this deposit, shows it to be of quite recent date.

I am inclined to think, from the appearance of the locality, that this iron-gravel occupies what was once the upper or shallow end of the bed of a mill-pond; at all events the character of the deposit is such as we might perhaps expect to find in such a situation.

V.—ON THE GRAPTOLITE FAMILY DICHOGRAPTIDÆ, LAPW.

By Dr. OTTO HERRMANN.[1]

[Translated and Abridged by W. S. DALLAS, F.L.S.]

Sub-order RHABDOPHORA, Allm. Group GRAPTOLITIDÆ, Lapw.
Family DICHOGRAPTIDÆ, Lapw.

Hydrosoma bilaterally developed. Branches regular, always furnished only with a single series of hydrothecæ (Monoprionidian). Hydrothecæ rectangular, touching one another, their inferior margin slightly curved. Sicula generally persistent; its free, pointed, downwardly directed end at the proximal extremity of the hydrosoma.

In 1851 M'Coy (Brit. Pal. Foss. p. 9) proposed the generic name *Didymograptus* for two-branched species with one row of cells "sometimes on the inner, sometimes on the outer side of the branches." Nearly at the same time Geinitz established his genus *Cladograptus* to include all two-armed or furcate Graptolites. These two denominations have been employed in various senses by succeeding authors, and considerable confusion has resulted. Hall[2] remarked that these genera contained at least two distinct types, and proposed to retain the name *Didymograptus* for such forms as *D. Murchisoni*, Beck, and to give that of *Cladograptus* to *Didym. divaricatus*, Hall, and its allies. His genus *Dicranograptus* applied to forms like *D. ramosus*, Hall, may be dropped.

In 1871 Hopkinson[3] separated such forms as *Didymograptus* (*Cladogr.*) *Forchhammeri* under the generic name of *Dicellograptus*. He adopted Hall's view of the nature of *Didymograptus*, abolished the name *Cladograptus* as a designation of two-branched Graptolites, and accepted Hall's name *Dicranograptus*. The two-branched Graptolites were thus divided into three genera:—

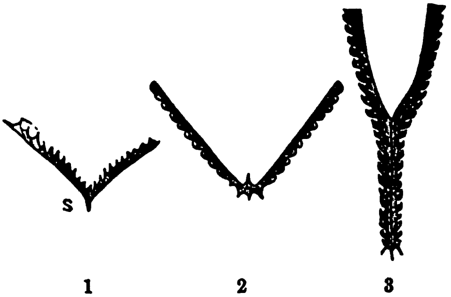

FIG. 1. *Didymograptus vacillans*, Tullberg.
„ 2. *Dicellograptus Forchhammeri*, Geinitz.
„ 3. *Dicranograptus ramosus*, Hall.

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[1] Abridged from the third chapter of Dr. Herrmann's paper in the Nyt Magazin for Naturvidenskaberne, vol. xxix. pp. 124—214. (See also GEOL. MAG. 1885, Dec. III. Vol. II. pp. 406 and 448.)

[2] Introduction to the Study of the Graptolites, Albany, 1868, p. 234.

[3] GEOL. MAG. 1871, Vol. VIII. p. 20, Pl. I.

1. *Didymograptus*, M'Coy (belonging to Lapworth's family Dichograptidæ) with such forms as *D. Murchisoni*, Beck and *D. vacillans*, Tullb. (Woodcut, p. 13, Fig. 1).
2. *Dicellograptus*, Hopk. (of the family Dichograptidæ, Lapw.) with such forms as *D. Forchhammeri*, Gein. (Fig. 2).
3. *Dicranograptus*, Hall (of the family Dicranograptidæ, Lapw.) with such forms as *D. ramosus*, Hall (Fig. 3).

To these may be added the still somewhat problematical genus of the family Dichograptidæ:—

4. *Janograptus*, Tullb., with such forms as *Janograptus laxatus*, Tullb. (see p. 16).

The following genera are adopted by the author:—

Genus I. DIDYMOGRAPTUS, M'Coy.

Hydrosoma bilaterally symmetrically developed, consisting of two simple branches diverging at an angle of 70°—180°. Sicula well preserved and always visible. The two primordial buds originate in the neighbourhood of the broad end of the sicula. Lower Silurian.

Species.

a. Type *Didymograptus patulus*, Hall.

1. *Didymograptus patulus* (Hall), Nich., Hopk. and Lapw., Brögger.

Graptolithus patulus, Hall, *D. hirundo*, Salt., Nich.

Angle of divergence about 180°.

Horizons and Localities.—Quebec Group, Canada; Middle and Upper Arenig, St. Davids; Skiddaw Slates, North of England; lower part of the *Phyllograptus*-shales, Norway; *Phyllograptus*-shales, Skåne and West Gothland.

2. *Didymograptus constrictus* (Hall), Linnars., Lapw., Brögg.

Graptolithus constrictus, Hall.

Quebec Group, Canada; Lower Graptolite shales, Skåne; *Phyllograptus*-shales, Norway.

3. *Didymograptus extensus* (Hall), Nich., Hopk., and Lapw., M'Coy, Brögg.

Graptolithus extensus, Hall.

Quebec Group, Canada; Lower Arenig (Wales); doubtfully in the Lower Bala of Australia; Lower part of *Phyllograptus*-shales, Norway.

4. *Didymograptus euodus*, Lapw. (and Hopk.).

D. extensus, var. *euodus*, Lapw.

Hor. and Loc.—Lower Llandeilo, Wales.

5. *Didymograptus arcuatus* (Hall).

Graptolithus arcuatus, Hall.

Quebec Group, Canada.

6. *Didymograptus extenuatus* (Hall), Lapw.

Graptolithus extenuatus, Hall.

Quebec Group, Canada.

7. *Didymograptus similis* (Hall), Lapw.

Graptolithus similis, Hall.

Quebec Group, Canada.

8. *Didymograptus superstes*, Lapw.

Lower Bala, Ireland; doubtfully near Albany, N.Y.

9. *Didymograptus nitidus* (Hall), Nich., Ether., Lapw.

Graptolithus nitidus, Hall.

Quebec Group, Canada; Skiddaw Slates; Arenig, Australia; doubtfully in *Phyllograptus*-shales, Norway.

10. *Didymograptus suecicus*, Tullb., Lapw., Brögger.

Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway ?

b. Type *Didymograptus Murchisoni*, Beck.

11. *Didymograptus Murchisoni* (Beck), Baily, Törnquist, Hopk., Nich., Trom. and Lebesc., Lapw., Tullb.

Graptolithus Murchisoni, Beck, Boeck.
Prionotus (?) *geminus*, His.
Graptolithus geminus, Scharenb., Kjerulf.
Didymograptus furcillatus, Hopk. and Lapw.

Angle of divergence about 40°.

Lower Llandeilo, Wales; *Didymograptus-Murchisoni* zone (Et. 4.) Norway, Skåne, France, Portugal.

12. *Didymograptus indentus* (Hall), Hopk. and Lapw., Brögger, Tullb.

Quebec Group, Canada; Upper Arenig, Wales; *Phyllograptus*-shales, Norway; zone with *Tetragraptus*, Skåne.

13. *Didymograptus indentus*, var. *nanus*, Lapw. and Hopk.

D. geminus, Nich.

Skiddaw slates, N. England; Upper Arenig, Wales; Lower and Middle Llandeilo, Wales.

14. *Didymograptus minutus*, Törnquist, Lapw.

Phyllograptus-shales, Dalecarlia.

15. *Didymograptus bifidus* (Hall), Nich., Hopk., and Lapw., Brögger, Tullb.

Angle of divergence 15°–20°.

Quebec Group, Canada; Skiddaw Slates, N. England; Upper Arenig, Wales. A somewhat divergent form in *Phyllograptus*-shales, Norway; zone with *Phyllograptus typus*, Skåne; Upper Arenig, N. England.

c. Type *Didymograptus fasciculatus*, Nich.

16. *Didymograptus fasciculatus*, Nich., Lapw.

Upper part of Skiddaw Slates.

17. *Didymograptus arcuatus* (Hall), Nich.

With a process opposite to the sicula. Quebec Group, Canada.

d. Type *Didymograptus pennatulus* (Hall).

18. *Didymograptus pennatulus* (Hall), Hopk. and Lapw.

Angle of divergence nearly 180° (Hall).

Quebec Group, Canada; Lower Arenig, Wales.

19. *Didymograptus sparsus*, Hopk., Lapw.

Lower Arenig, Wales.

20. *Didymograptus gibberulus*, Nich., Lapw.

Lower part of Skiddaw Slates, N. England.

e. Type *Didymograptus affinis*, Nich.

21. *Didymograptus affinis*, Nich., Hopk. and Lapw., Törnquist.
Angle of divergence 90°–150°.
Skiddaw Slates, N. England; Upper Arenig, Wales; doubtfully in *Phyllograptus*-shales, Dalecarlia.

22. *Didymograptus filiformis*, Tullb., Lapw., Brögg.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway.

23. *Didymograptus Nicholsoni*, Lapw., Hopk. and Lapw.
D. serratulus, Nich.
Upper Arenig, Wales; upper part of Skiddaw Slates, N. England; doubtfully in *Phyllograptus*-shales, Norway.

24. *Didymograptus pusillus*, Tullb., Lapw., Brögger.
Angle of divergence 145°–165°.
Tetragraptus-zone, Skåne; ? *Phyllograptus*-shales, Norway.

25. *Didymograptus serratulus* (Hall), ? Lapw.
Hudson's River Group, New York; ? Utica Slates, New York.

26. *Didymograptus striatulus*, Linnarsson, Nich., Lapw.
Lower Graptolite shales, West Gothland.

f. Type *Didymograptus V-fractus*, Salter.

27. *Didymograptus V-fractus*, Salt., Nich., Lapw., Brögg., Tullb.
Skiddaw Slates, N. England; *Tetragraptus*-zone, Skåne; Lower part of *Phyllograptus*-shales, Norway.

28. *Didymograptus balticus*, Tullb., Lapw.
Resembles the preceding.—Angle of divergence 60°–105°.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway.

29. *Didymograptus Pantoni*, M'Coy, Salt., Ether., Lapw.
Skiddaw Slates, N. England; Australia.

30. *Didymograptus vacillans*, Tullb., Lapw., Brögger.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway.

31. *Didymograptus*, sp. (*Hisingeri*, Baily). Lower Bala, Ireland. One of the latest species of *Didymograptus*.

Genus II. JANOGRAPTUS, Tullberg (Geol. För. Förh. vol. v. p. 314).

From the usually indistinct sicula two branches issue in opposite directions, or the whole hydrosoma is formed only of one branch. The sicula is probably pressed into one branch. The angle of divergence is very various. Hydrothecæ as in *Didymograptus*.

The genus, which is somewhat problematical, is one of the latest of the Dichograptidæ. Its structure shows a remarkable agreement with that of an irregularly developed Monograptid (*M. lobiferus*, M'Coy), in which a second branch may sometimes be produced.

1. *Janograptus laxatus*, Tullberg.
Gymnograptus Linnarssoni-zone, Skåne. A *Janograptus* is also mentioned in other *Glossograptus*-zones.

Other forms may be regarded as proceeding from a *Didymograptus*. The two branches may divide dichotomously, producing a four-branched form (*Tetragraptus*); or branchlets may issue from the two branches (*Trichograptus*, etc.). The following genera come under the latter category :—

Genus III. Trichograptus, Nicholson.

Hydrosoma bilaterally subsymmetrically developed. Two principal branches on the celluliferous side, with a series of branchlets which remain undivided. Hydrothecæ of the type of *Monograptus Nilssoni*, Barr.

1. *Trichograptus fragilis*, Nich., Lapw.
Upper part of Skiddaw Slates, N. England.
2. *Trichograptus retroflexus* (Brögger).
Bryograptus retroflexus, Brögg.
Upper part of *Dictyograptus*-shales, Norway.

Genus IV. Bryograptus, Lapworth.

Hydrosoma bilaterally subsymmetrical, consisting of two composite branches, diverging at a small angle from a distinct sicula. From the two principal branches composite branchlets issue at small but irregular intervals.

1. *Bryograptus Kjerulfi*, Lapw., Brögger.
Graptolithus tenuis, Kjerulf.
Dictyograptus-shales, Norway.
2. *Bryograptus Callavei*, Lapw. Upper Cambrian, Shropshire.
3. *Bryograptus ramosus*, Brögger.
Lower part of the *Ceratopyge*-shales, Norway. A very similar species in abundance in shales below the *Phyllograptus*-shales at Christiania.

Genus V. Pterograptus, Holm (Öfv. Kongl. Vet. Akad. Förh. 1881, p. 74).

The hydrosoma issues from the wide end of the sicula. On the two primary branches simple secondary branches arise from a number of the hydrothecæ towards the apex, and these are bent alternately to right and left of a plane passing through the primary branch, and turn their cell-bearing side towards this plane.

Fig. 6*b*.

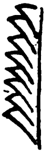

Fig. 6*a*.

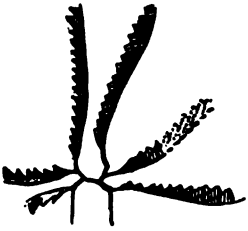

Fig. 5.

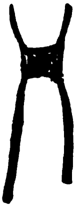

Fig. 4.

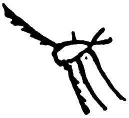

Fig. 4. *Pterograptus dilaceratus*, sp. nov.
Phyllograptus-shales, Galgenberg, Christiania.
,, 5. *Tetragraptus approximatus*, Nich.
Phyllograptus-shales, Fure, Ringerike, Norway.
,, 6*a*. *Dichograptus Sedgwickii*, Salter (formation and locality as in Fig. 4.)
,, 6*b*. Part of a branch of Fig. 6*a*, enlarged twice nat. size to show the form of the hydrotheca.

1. *Pterograptus elegans*, Holm, Tullberg.

Graptolithus Murchisonii, Boeck; *G. gracilis*, Kjerulf.

Primary branches diverging in curves at an angle of 50°-60°.

Didymograptus Murchisoni-zone (Et. 4), Norway; zone with *D. Murchisoni*[1] *geminus*, Skåne.

2. *Pterogaptus acutus* (Hopk.), Holm.

Ptilograptus acutus, Hopk.

Primary branches diverging at an angle of 30°-40°.

Lower Llandeilo, Wales.

3. *Pterograptus* (?) *dilaceratus*, sp.n. (Woodcut, p. 17, Fig. 4.)

Hydrothecæ as in *P. elegans*, Holm. Secondary branches narrow and thin, never so rigid as in that species. Angle of divergence of the two primary branches probably about 180°. The hydrosoma is always fragmentary (sicula not seen attached). Not unfrequently a primary branch is met with, from the hydrothecæ of which closely approximated branchlets project. It is sometimes rolled up circularly, often only gently curved, or bent and broken into a zigzagged form.

Genus VI. PLEUROGRAPTUS, Nicholson.

Secondary branches proceed from both sides of the primary branches, and themselves again give off branches; primary branches diverging at an angle of about 180°.

Referred by Lapworth to the Nemagraptidæ.[2]

1. *Pleurograptus vagans*, Nich.

Skiddaw Slates, N. England; *Phyllograptus*-shales, Norway.

2. *Pleurograptus lineuris* (Carr.), Nich., Lapw.

Cladograpsus linearis, Carruthers.

Upper Llandeilo, England; Hartfell Shales, Scotland.

3. *Pleurograptus radiatus*, Lapw. Hartfell Shales, Scotland.

The four-branched forms resulting from the dichotomous division of a *Didymograptus* constitute

Genus VII. TETRAGRAPTUS, Salter.

Hydrosoma bilaterally symmetrically developed, consisting of four simple equivalent branches. A central disc may or may not be present.

The four-branched forms may be brought into two natural groups:

a. The two short branches issuing from the broad end of the sicula diverge at an angle of about 180°, *e.g.* *T. quadribrachiatus* (Hall). Thus is formed a funiculus uniting the two halves of the hydrosoma, but this may be reduced until it nearly disappears (*e.g.* *T. Hicksii*, Hopk., and *T. Halli*, Hopk.).

β. The two branches which originate from the sicula diverge at an angle of ∠180° (*T. fructicosus* (Hall)).

Group *a*.

1. *Tetragraptus quadribrachiatus* (Hall), Nich., Ether., Hopk. and Lapw., Linnars., Törnq., Brögg., Herrm., Tullb.

Graptolithus quadribrachiatus, Hall, M'Coy.

Tetragraptus crucialis, Salt.

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[1] *Phyllograptus*-shales, Norway.

[2] See Notes on British Graptolithes, by C. Lapworth, F.G.S., GEOL. MAG. 1873, Vol. X. p. 558, and Table I.

Quebec Group, Canada; Skiddaw Slates, N. England; Arenig, Australia; Middle Arenig, Wales; *Phyllograptus*-shales, Norway, Dalecarlia; *Tetragraptus*-zone, Skåne.

2. *Tetragraptus Halli*, Hopk. and Lapw.

Middle Arenig, Wales.

3. *Tetragraptus Hicksii*, Hopk. and Lapw.

Middle Arenig, Wales.

4. *Tetragraptus serra* (Brongn.), (Gein.), Hopk. and Lapw., Törnq.

Fucoides serra, Brongn.
Cladograptus serra, Gein.
Graptolithus bryonoides, Hall.
Tetragraptus bryonoides, Salt., Nich.
Didymograptus bryonides, Carr., M'Coy.

Arenig and equivalents in Wales, N. England, Canada, Norway, Skåne, Westgothland, and Dalecarlia; Newfoundland.

5. *Tetragraptus denticulatus* (Hall), Lapw.

Quebec Group, Canada; Silurian, Victoria ?

6. *Tetragraptus crucifer* (Hall), Nich., and Lapw.

With a central disc.

Quebec Group, Canada; Skiddaw Slates, N. England.

7. *Tetragraptus alatus* (Hall), Lapw.

With a central disc.

Quebec Group, Canada.

8. *Tetragraptus Headi* (Hall), Nich., Lapw.

With a central disc.

Quebec Group, Canada; Newfoundland; Lower part of Skiddaw Slates, N. England.

9. *Tetragraptus caduceus* (Salt.).

Didymograptus caduceus, Salt., Nich., M'Coy.
Phyllograptus similis, Hall.
Graptolithus Bigsbyi, Hall.
Tetragraptus Bigsbyi, Linnars., Lapw.

Skiddaw Slates, N. England; Quebec Group, Canada; *Phyllograptus*-shales, Norway, Skåne; Australia (Ether., Ann. Mag. N. H. ser. 4, vol. xiv. pl. iii. figs. 3, 4).

10. *Tetragraptus approximatus*, Nich., Lapw. (Woodcut, p. 17, Fig. 5.)

Quebec Group, Canada; *Phyllograptus*-shales, Norway. Norwegian specimens differ in not having the branches so close together as in Nicholson's figure; the curvature on both sides of the branches is sharper, and the branches do not so soon become parallel, and do not continue so exactly parallel as Nicholson indicates. One specimen from near Fure, in Ringerike, showed traces of a central disc.

Group *β*.

11. *Tetragraptus fructicosus* (Hall), Lapw., Brögg., Herrm., Tullb.

Graptolithus fructicosus, Hall.
Didymograptus fructicosus, Ether., M'Coy.

Quebec Group, Canada; Llandeilo Flags, Australia; *Phyllograptus*-shales, Norway; *Tetragraptus*-zone, Skåne; Arenig, Australia (according to Lapworth).

From *Tetragraptus* two different groups of forms may be derived. The four branches may divide dichotomously, producing hydrosomata with eight or more branches (*Dichograptus*, Salt.); or secondary branches may shoot forth from the four primary branches upon one or both sides. The latter is the case in the following five genera.

Genus VIII. Schizograptus, Nicholson.

Hydrosoma bilaterally subsymmetrical, composed of four primary branches, which issue in the form of a cross from the starting-point. Each of these branches developes a series of rigid branchlets which originate on each primary branch from the same side, and apparently do not again divide. Hydrothecæ as in *Monograptus sagittarius*, His. No central disc.

1. *Schizograptus reticulatus*, Nich., Lapw.
Dichograptus reticulatus, Nich.
Lower part of Skiddaw Slates, N. England.

Genus IX. Trochograptus, Holm (Öfv. Kongl. Vet. Akad. Förh. 1881).

Constructed exactly like the preceding genus, except that the secondary branches give off branchlets always upon the same side.

1. *Trochograptus diffusus*, Holm, Brögger.
Phyllograptus-shales (Et. 3, *b*), Norway.

Genus X. Ctenograptus, Nicholson.

This genus, provisionally established by Nicholson, probably belongs to this group. The fragment figured by Nicholson resembles a portion of *Trochograptus diffusus*, figured by Holm, except that the hydrothecæ appear to be essentially different.

1. *Ctenograptus annulatus*, Nich.
Dichograpsus ? annulatus, Nich.
Lower part of Skiddaw Slates, N. England.

Genus XI. Provisional.

1. *Graptolithus Richardsoni*, Hall, from the Quebec Group. The mode of division of the branches as shown by the fragment figured resembles that of *Ctenograptus*. But the commencement of the hydrosoma is unknown, and we have no knowledge of the number of primary branches.

Genus XII. Holograptus, Holm (*loc. cit.*).

Hydrosoma bilaterally subsymmetrical. From the four primary branches branchlets are given off on both sides at irregular intervals. Hydrothecæ as in *Didymograptus*.

1. *Holograptus expansus*, Holm.
Phyllograptus-shales, West Gothland.

Genus XIII. Goniograptus, M'Coy (Prodr. Pal. Vict. dec. v.)

1. *Goniograptus Thureaui*, M'Coy, Lapw.
Arenig, Australia.

These smaller genera scarcely contain more than a single species each, and probably in their case the establishment of genera has been carried too far. This opinion also seems to be held by Tullberg (Skåne's Graptoliter ii.). It would be better to regard them as subgenera of the two great genera *Didymograptus* and *Tetragraptus.*

All the many-branched Dichograptidæ may be conceived as originating from a *Tetragraptus* by repeated furcation. A division, repeated in all branches, produces eight-branched forms; further complete furcations give 16-branched forms and so on. Hitherto the 8-branched forms constituted the genus *Dichograptus,* Salt., and those with 16-32 branches the genus *Loganograptus,* Hall. But in considering the various forms with 8 and more branches, we are at once struck with an important contrast to those with 2 and 4 branches. The latter, when perfectly preserved, invariably possess only 2 and 4 branches; but in the many-branched forms a remarkable variation occurs in the number of branches; more and more frequently the full number is either not developed or exceeded, imperfectly or abnormally developed individuals become more and more numerous, so that the number of branches becomes of less and less value as a distinctive character. Thus in the multiramose species of the genus *Clonograptus,* Hall, the number of branches oscillates between 40 and 60 for the same species. The number of branches becomes finally so complicated as to be quite unimportant (*e.g. Clematograptus multifasciatus,* Hall). Thus the genus *Loganograptus,* Hall, with 16-32 branches appears to be quite arbitrary and artificial, and must be suppressed, unless we are prepared to establish a genus for every many-branched species. It has been proposed to refer all species with more than four branches to *Dichograptus,* Salt., which has hitherto included only 8-branched forms. But upon this the author would put a limitation, as there is in the many-branched forms a striking difference. "Thus either all the points of furcation are situated in the immediate vicinity of the sicula (*e.g. Dichograptus Kjerulfi,* Herrm., Fig. 8), while the more distant parts of the branches remain undivided; or there are greater distances between the individual points of furcation, so that the branches may divide throughout their whole length, and the points of furcation may depart far from the centre of the hydrosoma (*e.g.* Fig. 9)." For the latter forms Hall has proposed the name of *Clonograptus,* which may stand, and thus we get two homologous series forming the genera *Dichograptus,* Salt., and *Clonograptus,* Hall, each including forms with 8, 12, 16, and more branches.

Genus XIV. DICHOGRAPTUS, Salt. (modified).

Hydrosoma bilaterally symmetrical. From the broad end of the sicula, which is directed upwards, issue two short oppositely diverging branches, which fork. Of the four branches thus produced, all or a part may again divide dichotomously once or several times *at very short distances,* so that more than four equivalent, simple branches are produced. The proximal parts of the hydrosoma are frequently enclosed in a central disc. Hydrothecæ as in *Didymograptus,* M'Coy.

1. *Dichograptus octobrachiatus* (Hall), Nich., (M'Coy), Lapw., Brögg. (Fig. 7.)

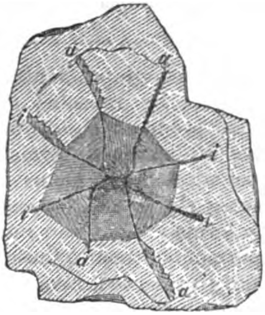

Fig. 7. *Dichograptus octobrachiatus*, Hall, from the Phyllograptus-shales, Galgenberg, Christiania (natural size).

Graptolithus octobrachiatus, Hall.
Graptolites (*Didymograptus*) *octobrachiatus*, M'Coy.
Loganograptus Kjerulfi, Herrm. *ex parte.*

The central disc may or may not be present. In the typical condition the species has eight branches, but specimens are frequent with more or fewer branches.

Quebec Group, Canada; lower part of Skiddaw Slates, N. England; *Phyllograptus*-shales, Norway; Arenig, Australia.

2. *Dichograptus octonarius* (Hall), Lapw.

Graptolithus octonarius, Hall.

Central disc unknown. Quebec Group, Canada.

3. *Dichograptus Sedgwickii*, Salt. (Figs. 6*a*, 6*b*.)

Figured but not described by Salter (Q.J.G.S. vol. xix. p. 138).

The author describes the species:—

In the typical condition the hydrosoma consists of eight simple, curved branches, which are arranged as in *D. octobrachiatus*, Hall. There is in this species the same variation in the number of branches as in *D. octobrachiatus*, which is its nearest ally, the differences between them consisting in the curvature of the branches, and the habit of the hydrothecæ. Of the latter there are eight in a length of ten millim. Their lower border is curved and forms with the axis an angle of 10°—12° at the proximal end, of about 30° at the distal end. The apertural angle is about 90°, and the hydrothecæ, which are about one-half longer than broad, are half free, appearing as pointed, nearly perpendicular teeth (Fig. 6*b*). No central disc has been observed either in English or Norwegian specimens.

Skiddaw Slate (lower part), N. England; lower part of *Phyllograptus*-shales, Norway.

4. *Dichograptus Kjerulfi* (Herrm.) (Woodcut, p. 23, Fig. 8).

Loganograptus Kjerulfi, Herrm. *ex parte.*

In 1882 (Nyt Mag. for Naturv. xxvii. pp. 341-362) the author described and figured, under the name of *Loganograptus Kjerulfi*, a number of forms which subsequent study showed him must be separated. The eight-branched forms, with some abnormally developed examples, are referred to *D. octobrachiatus*, Hall. The forms furnished in the typical state with twelve branches are to be regarded as a distinct species, and that these examples cannot be referred either to *D. octobrachiatus* (Fig. 7) or to *D. Logani*, Hall, seems to the author to follow from the facts that in some localities only eight- and many-branched forms (*D. Logani*, Hall) have been found (*e.g.* Australia and Canada), in others only those with numerous branches (*e.g.* the Australian localities examined by R. Etheridge, jun.), and in other localities again only eight-branched forms. In the locality investigated by the author (Galgenberg, Christiania) the forms with 8 and 12 branches occur together, and he considers that here two different species are associated. Further, the twelve-branched forms constitute a bilaterally symmetrical species, and the number of normally developed examples as compared with abnormal ones seems to indicate their distinctness.

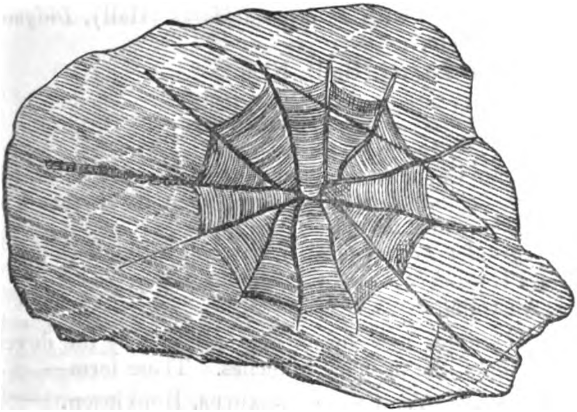

FIG. 8. *Dichograptus Kjerulfi*, Herrmann, Phyllograptus-shales, Galgenberg, Christiania (natural size).

Description.—Hydrosoma bilaterally symmetrical, consisting of 12 branches when typically developed. From a sicula, which usually persists as a rounded knob, issue 2 short branches, which bifurcate first into 4 and then into 8 branches. Of these 8 branches, 4 again divide, and these four are almost always those situated furthest from the plane of symmetry, *i.e.* the inner branches of each half of the hydrosoma of an octobrachiate form (FIG. 7*i*). The branches are slender, thinnest in the neighbourhood of the sicula. The full number of branches is frequently not attained, and rarely exceeded. The central part of the hydrosoma is almost always enclosed in a chitinous disc. The hydrothecæ are rarely to be seen within the disc. There are 9 of them in a length of 10 millim. At the proximal end they form with the axis an angle of 13°—15°, at the distal end one of about 35°. They are three times as long as broad, and about one-third free. The lower border is curved. Aperture-angle 55°.

It has been thought that the forms described by the author (*loc. cit.*), constituting a continuous series of examples with from 5 to 14 branches, were to be regarded as individuals of different ages, the highest number of branches indicating the greatest age. The author regards this view as untenable. No difference is to be detected in the thickness and length of all the branches, such as would occur if any of them were formed subsequently to the rest, whereas it might be expected that the supposed younger branches would be observable when they had just sprouted, and before they reached the margin of the disc. It is also difficult to imagine how any such subsequent increase could be brought about, as the branches originate by bifurcation, which usually occurs only at the top of a branch. But the notion is disposed of by the fact that young individuals occur with 8, 9, and 12 branches, just as in full-grown examples.

Dichograptus Kjerulfi is found in the lower part of the *Phyllograptus*-shale (Kjerulf's Lower Graptolite-shales, Brögger's Etage 3*b*), and occurs in great abundance in a thin bed in the Galgenberg, near Christiania, associated with *D. octobrachiatus* (Hall), *Didymograptus constrictus* (Hall), etc.

5. *Dichograptus Logani* (Hall), Nich.

Graptolithus (*Loganograptus*) *Logani*, Hall.
Graptolites (*Didymograptus*) *Logani*, M'Coy.
Loganograptus Logani, Lapw.

Quebec Group, Canada; Skiddaw Slates (lower part), N. England; Australia. *D. Logani*, Etheridge, Ann. Mag. N. H. ser. 4, vol. xiv. pl. iii. fig. 12, is doubtful.

5 *b*. *Dichograptus Logani* (Hall.), var. *australis* (M'Coy).

Grapt. (*Didymogr.*) *Logani*, var. *australis*, M'Coy.

Arenig, Australia.

From *Dichograptus* new forms may proceed by the development of branchlets upon the primary branches. These form—

Genus XV. Clematograptus, Hopkinson.

Hydrosoma much ramified, bilaterally subsymmetrical. From a short funiculus issue a great number of primary branches, from which numerous branchlets spring on one or both sides, at irregular distances, often closely packed together. Hydrothecæ as in *Dichograptus*. No central disc.

1. *Clematograptus implicatus*, Hopk., Lapw.

Loganograptus? implicatus, Hopk.

Middle Arenig, Wales.

2. *Clematograptus multifasciatus* (Hall), Hopk. and Lapw.

Graptolithus multifasciatus, Hall.

Hudson River Group, New York.

D. (*L.*) *Logani*, Etheridge (Ann. Mag. N. H. ser. 4, vol. xiv. pl. iii. fig. 11), from Australia, probably belongs to this genus.

Genus XVI. Clonograptus, Hall.

Hydrosoma bilaterally subsymmetrical, consisting of more than four simple branches produced by dichotomous division. The spaces between the furcation-points are larger than in *Dichograptus*. Central disc never present.

There is some uncertainty about the species of this genus. Hall discovered in a loose block in America a form with 16 branches, which certainly belongs to this genus (*Cl. Milesi*, Hall); this is figured, but not described, by Hall. Nicholson found in the Skiddaw Slates two specimens of a form which must also be referred to this position. They possess a great number of branches (*C. multiplex*, Nich.). In the Norwegian *Phyllograptus*-shale the author has found a considerable number of specimens agreeing in character with the above, and especially with Nicholson's species, six of which have 8, and four 16 branches, while many others vary between 8 and 16 branches (Fig. 9). These were formerly identified by the author with *C. Milesi* (Hall), but he now regards this identification as doubtful. Nicholson's genus *Temnograptus* is not sufficiently distinct from *Clonograptus*.

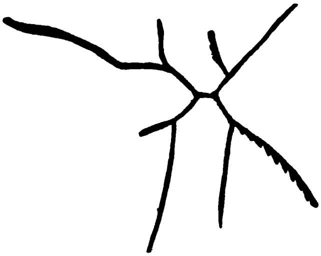

Fig. 9.

Fig. 9. *Clonograptus multiplex*, Nicholson, Skiddaw slates, Peel-Wyke, Bassenthwaite, Cumberland.

1. *Clonograptus Milesi*, Hall.
   Graptolithus Milesi, Hall.
   Temnograptus Milesi, Nich.
2. *Clonograptus multiplex* (Nich.). (Fig. 9.)
   Dichograptus multiplex, Nich.
   Temnograptus multiplex, Nich., Lapw.

Skiddaw Slates, N. England.

3. *Clonograptus flexilis* (Hall), Nich., Lapw.
   Graptolithus flexilis, Hall.

Quebec Group, Canada.

4. *Clonograptus rigidus* (Hall), Nich., Lapw.
   Graptolithus rigidus, Hall.
   Graptolithus abnormis, Hall.

Quebec Group, Canada; *Phyllograptus*-shale, Norway.

5. *Clonograptus ramulus* (Hall), Lapw.
   Graptolithus ramulus, Hall, Törnq.

Quebec Group, Canada; *Phyllograptus*-shale, Dalecarlia.

Graptolithus Richardsoni, Hall, does not belong to this genus.

6. *Clonograptus tenellus* (Linnars.)
   Dichograptus ? tenellus, Linnars., Lapw.
   Trichograptus tenellus, Nich.

Olenus-shale, West Gothland.

The most ancient of known Graptolites, described by Linnarsson in 1871, as *Dichograptus ? tenellus*. Tullberg regards it as a *Bryograptus;* Nicholson refers it to his genus *Trichograptus*. The discoverer of the species noticed that its ramification agreed with that of *Clonograptus flexilis;* and until more perfect specimens are obtained, it may take its place here.

VI.—AN INQUIRY INTO THE RATE OF EROSION OF THE SEA-COASTS OF ENGLAND AND WALES, AND THE INFLUENCE OF THE ARTIFICIAL ABSTRACTION OF SHINGLE OR OTHER MATERIAL IN THAT ACTION.

By C. E. DE RANCE, F.G.S., and W. TOPLEY, F.G.S., Secretaries.[1]

The Committee has during the past year received several Returns relating to the south and east coasts of England. Most of those relating to the coast south of the Thames are printed.

The thanks of the Committee are especially due to Major-General Sir A. Clarke, who has instructed the Officers of the Royal Engineers stationed around the coast to supply the Committee with such information as they may possess or be able to obtain. Further returns are expected from the same department and from other official sources; the Committee therefore think it best to defer any general report until more complete information is obtained.

The Memorandum drawn up by Mr. J. B. Redman so fully sets forth the work of the Committee, and the importance of the inquiry referred to it, that this is now printed.

The Memorandum by Mr. G. Dowker on East Kent gives a sufficiently complete account of the changes of the coast in this district; changes which are of especial historical importance and interest.

Mr. Whitaker has drawn up a list of works relating to the coast-changes of England and Wales, which will be of great service to the Committee and to those who may assist in the work.

The Committee would again ask for the assistance of any who by long residence or other means have special knowledge of changes on any part of the English and Welsh coast. Printed forms of questions can be obtained from any member of the Committee.

Extracts from the MEMORANDUM BY MR. J. B. REDMAN, M.Inst.C.E.

That the erosion of our south-eastern coasts by the action of wind and waves has been assisted and increased by artificial agency, by removal of material and by the treatment of works of defence in a selfish spirit, unaccompanied by concerted action, resulting in injury to adjoining frontages for the benefit of those operated on, can be copiously illustrated by the records of our public departments, such as the Admiralty, Woods and Forests or Works, the Board of Trade, the War Office, and the Trinity Corporation, as well as by those of nearly every harbour board, river conservancy, or local drainage and sewage authority. And this fact is portrayed in a special literature of its own, the Blue Books of the House of Commons, for the various tidal harbours' reports, inaugurated by the persistent agitation of the late Joseph Hume, M.P., as well as those on harbours of refuge, lighthouses, and shipping, give incidentally numerous isolated cases showing how much this really imperial question has been overlooked or confused by a division of authority, and the struggles with lords of the manor, illustrated by a number of well-known cases, adds additional exemplification.

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[1] Being the substance of a Report laid before the British Association at Aberdeen, and read in Section C. Geology, 1885.

The legal aspect of this question has been recently ably treated on by a republication of "Hall's Essay on the Rights of the Crown in the Sea-shore," by Richard Loveland Loveland, of the Inner Temple, in 1875, and this work shows well the imperial character of the inquiry deputed to the British Association Committee on the Erosion of the Sea Coasts of England and Wales.

As regards the wholesale removal of shingle and boulders from marine spits and moles, it is only necessary to refer to such cases as the quarrying of cement stones from the foreshores on either side of Harwich, from the Beacon cliff to the southward, and from the Felixstow cliffs to the northward, only stopped by the persistent efforts made by Captain Hewett's successor in the North Sea Survey, the late Admiral Washington, and others. For illustration of this pernicious practice and the deplorable results frequently entailed this case suffices. Again, on the northern side, the indiscriminate removal of shingle from the northern breakwater of Harwich harbour (Landguard Point) for ballastage by the lord of the manor has been the fruitful source of litigation. Similar results from similar practices at Spurn Point, at the mouth of the Humber, have been entailed. In effect, this natural shingle mole, defending the entrance to the most important harbour on our eastern coast, was nearly breached in consequence.

Next to the removal for ballastage, the most fertile cause is removal of material for road-making and for building purposes, and when in the neighbourhood of a large town this becomes, from the enormous quantity removed in the aggregate, sufficient to tell eventually on the oscillating natural foreshore protection. Take the case of Hastings: for the last half-century there has been a constant draw on the material for such purposes. The quantity used must be enormous, and in effect the new portion of the town may almost, without figure of speech, be described as in a large measure built out of the sea. About 1836 Hastings was separated from St. Leonards by a small marshy bottom, with a rill of water running through it, called the "Priory Marsh," and during that year the sea was excluded by the erection of a vertical stone wall joining the esplanade terraces, and the two towns became what it is now, one big town. Since that wall was erected the shingle in front of it has, from various causes, become much attenuated, the groynes destroyed, and the sea has, it is said, in places got under the sea walls. So great has been the loss in the bay to the eastward, where is situate the old portion of the town, the fishermen's quarter, that a general exodus of that industry to Rye, or elsewhere, has been threatened.

A second groyne is being constructed from the base of the cliff below the castle (where a similar work formerly existed) at a very great cost, in order to promote accumulation of shingle along the Hastings frontage, and to bring about again the old state of things.

The argument made use of by many owners of property here, as elsewhere, to the effect that removal of shingle for building purposes must be inappreciable (as however great the abstraction for such purposes, millions of tons renew the shore after a change of wind) is made in evident forgetfulness or ignorance of the fact that these abstractions from and renewals to the natural "fulls" of beach, alternately reduce and increase what is a circulating medium of defence, moving in opposite directions up and down channel, with a preponderating movement up-channel due to prevalence of south-west winds, and that such a constant drain on a natural defence, however recuperative, must tell in the long run.

The removal of boulders from the foreshore seaward of the summit shingle neap and spring "fulls," either for road-making or for manufacturing purposes, not only loosens the foreshore, and renders it, thus disintegrated, less able to resist the stroke of the wave, but in many cases, such as the "Chenies" rock off Sheerness, and the "Septaria" blocks off Harwich, the material formed natural groynes and breakwaters, and their removal, in reference to shore conservancy, was most suicidal.

Another fertile source of accelerated erosion of a special locality is the erection of a close pier for a harbour entrance, and of large and lofty groynes for accumulating shingle, looking only to the protection of an isolated frontage, and without reference to the attendant abstraction of material to the leeward of such works, from the absolute stoppage of the material on its way to the less favoured locality. The case is parallel to the last, as the oscillating medium is laid under heavier contribution for a favoured locality, and is gradually starved for the neglected neighbour to leeward.

Folkestone may be cited as a principal delinquent of this class, due to the elongation of the close pier to the windward or westward of its harbour, which half a century back was a trap for shingle, and a fisherman's first task in the early morning, prior to that, was to excavate a channel through the newly-arrived shingle to get his boat through and out to sea. The resultant accumulation of shingle to windward forms the tongue of land on which stands the "Pavilion," etc.

Now, in "East Wear" Bay there is an almost entire absence of shingle, and the resultant falls of the chalk undercliff take place at so alarming a rate that the very existence of the South-Eastern Railway is jeopardized. That this action is not due to the Admiralty Pier at Dover is shown by the entire absence of shingle to windward of that work, but in its place a remarkable extension of the silty foreshore has taken place, gradually diminishing towards Folkestone. Eastward of Dover we have similar results from the same cause; from the Castle Jetty to St. Margaret's the base of the lofty chalk cliff is now washed and abraded by the waves, and the lower *débris* and shingle, forming an undercliff carriage-way into Dover some thirty years back, has now entirely disappeared.

We may be asked to suggest a remedy, but this, perhaps, is beyond the province of this Memorandum; but as regards the old stereotyped plan of building a solid pier out from the shore, for communication therewith from vessels, or for protection of the outfall of a tidal river, it has been suggested that there are numerous cases, where a moving beach has to be crossed, that it would be better to commence the solid work altogether seaward of the shingle "fulls," and connect it with open piling to the shore, and so as to leave the littoral movement of beach uninterfered with.

As respects groynes, there is hardly a watering-place on our southern coast where they have not become a burning *vexata quæstio* of the day, and at most of them illustrate the suggestion made more than thirty years back, that groynes cut up a shore into a multitude of bays, with a repletion of material on one side and deep water on the other, and would have had a better substitute in a sea-wall that allowed the shingle to pass freely backwards and forwards along its face. Such was the experience with the frontage of Romney Marsh, defended by Dymchurch sea-wall, 3½ miles in length, where the old system of groynes, which cut up the frontage into an interminable number of bays, was abandoned about forty years back in favour of the present stone slope.

The system of groynes at Brighton, for some isolated points, appeared to have answered well when the supply arriving at that town of shingle from the westward was uninterfered with, but a change occurs when the system was continued to Hove, or West Brighton, in thickening quantities. The material arriving was a constantly diminishing one, from the fact that the Shoreham Gas Works, erected under an Act of Parliament on the "live" beach between the harbour and the sea, were found to stand upon a somewhat unstable base, with a fickle sea defence, unless supplemented by artificial works. Groynes on an extended scale were erected, which treated West Brighton in the same ungenerous spirit entertained in former days for Rottingdean, for the sake of and advantage of Kemp Town. The encroachment of the sea to the leeward side of the groynes, on the esplanade lawns, has necessitated the erection of an esplanade wall.

NOTICES OF MEMOIRS.

Brief Notices of Papers Read before Section C. Geology, British Association Meeting, Aberdeen, 1885.

I.—The Chasm called the Black Rock of Kiltearn.

By William Watson.

THIS is a narrow ravine in conglomerate: its length is about 1¼ mile; its depth varies from 100 to 130 feet; its breadth at the top varies from 12 to 15 to about 30 feet. The river which flows through the ravine is the Altl-Gránda; it drains Glen Glass (above the ravine); the water flows into Cromarty Firth.

The author refers to popular views held to explain the formation of the ravine—earthquakes and fracture—and shows that these are inadequate. The ravine has clearly been produced by erosion, of which the marks are still visible on the sides; the difficulty is to explain how erosion could have produced a gorge of this kind without weathering action and floods having denuded the sides.

Above the gorge in Glen Glass was once a lake. This had been silted up to the height of about 80 feet with sand, washed out of the Glacial *débris* of the glen. When the barrier that confined the lake gave way, the river flowed over the surface of the conglomerate, carrying with it much sand from the lake silt, and using this as a means of rapidly eroding the rock. When the chasm was deep enough to prevent the floods from overflowing the banks, the sides could not be widened to any great extent. The disproportion between the deepening and widening process has been maintained, thus causing the steep-sided narrow glen. The excavation now going on is small, whilst the weather has some effect on the sides; so that ultimately there will be produced an ordinary valley.

II.—Notice of an Outline Geological Map of Lower Egypt, Arabia Petræa, and Palestine.

By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

THE map exhibited was enlarged from that which accompanies the author's book "Mount Seir, Sinai, and Western Palestine," giving a narrative of the expedition sent out into these countries by the Palestine Exploration Society in 1883-84. It embraces a region extending from the valley of the Nile on the west to the table-land of Edom (Mount Seir) and Moab, including the Jordan, Arabah Valley, and the mountains of Sinai. Its northern limit is the Lebanon. The following formations and divisions are represented:—

Recent.	1. Sandhills of Lower Egypt, the coast of Palestine, and Arabah Valley. 2. Alluvial Deposits of the Nile, the Ghor, and Jordan Valley. 3. Gravel of the Wâdy el Arabah.
Recent and Post-Pliocene to Pliocene.	1. Raised Beaches bordering the Gulfs of Suez and Akabah, the Isthmus of Suez, and borders of Palestine. 2. Ancient Deposits of the Salt Sea (Dead Sea). 3. Old Lake-beds of the Sinaitic Peninsula and Arabah Valley.
Eocene to Cretaceous.	1. *Upper Eocene.* Calcareous Sandstone of Philistia. 2. *Middle and Lower Eocene.* Nummulite Limestone. 3. *Upper Cretaceous.* Cretaceous Limestone. 4. *Cenomanian.* Nubian Sandstone.
Lower Carboniferous.	1. Limestone of Wâdy Nasb. 2. Desert Sandstone and Conglomerate.
Metamorphic Rocks (Archæan?).	Granite, Gneiss, and various kinds of Schist.
Modern Volcanic Rocks.	Basalt, Dolerite, etc.
Ancient Volcanic or Plutonic Rocks.	Granite, Porphyry, Felstone, Diorite, etc. Beds of Tuff and Agglomerate of Wâdy Haroun and Jebel esh Shomrah.

The main lines of fault and dip of the strata are also indicated.

As an outline of the scientific results which were arrived at by the members of the expedition, and which are represented on the map, had already been communicated to the Association,[1] it was not considered necessary to repeat them here, but the author wished to add that a topographical and geological map of the Arabah Valley on a scale of about six miles to one inch was in preparation, and would accompany the Geological Report now in the press for the Palestine Exploration Society. The topographical survey had been made by Major Kitchener, R.E., and Mr. John Armstrong (formerly sergeant-major, R.E.), and the geological details had been inserted by the author. In addition to these, several longitudinal geological sections illustrating the structure of various parts of this region, and numerous drawings would accompany the memoir.

III.—ON THE OCCURRENCE OF LOWER OLD RED CONGLOMERATE IN THE PROMONTORY OF THE FANAD, NORTH DONEGAL.

By Professor EDWARD HULL, LL.D., F.R.S., F.G.S.,
Director of the Geological Survey of Ireland.

THE district in which the Old Red Conglomerate occurs is formed of ridges and valleys of metamorphic rocks, consisting of beds of quartzite, schist, crystalline limestone, and trap, chiefly diorite. It lies between Lough Swilly and Mulroy Bay, and is washed on the north by the waters of the Atlantic. The remarkable tract of the Old Red Conglomerate, recently discovered by the officers of the Geological Survey, is far remote from any mass of the same formation, and it is unrepresented on any geological map hitherto published.

The beds consist of red and purple sandstones and conglomerates, made up chiefly of quartzite pebbles and blocks, but also containing others of limestone and trap; all derived from the surrounding metamorphic series. They occupy an area of over two miles in length and half a mile across, extending along the northern base of Knock Alla, a ridge of quartzite which traverses the promontory from side to side. The beds dip against the base of the mountain, against which they are let down by a large fault, and they terminate along their northern edge by an unconformable superposition on beds of quartzite and limestone. They reach a total thickness of about 800 feet.

From the position of these beds it becomes evident that they are unconnected with any of the recognized basins of Lower Old Red Sandstone, either in Scotland or Ireland, and may, therefore, be regarded as having been formed in an isolated basin, which, following the example of Dr. Geikie, I may be allowed to name "Lake Fanad." The tract will be a new feature on geological maps of Ireland.

IV.—ON ROCKS OF CENTRAL CAITHNESS.

By JOHN GUNN.

THE term "Central Caithness" is intended to embrace most of the parish of Halkirk and part of the parish of Watten. The upper part of the parish of Halkirk is covered by drift-gravel, underlying peat. At Loch More flagstones are presented. Below the lake may be traced the banks of what was once a great river. At Dirlot the rocks are sandstone, granite, gneiss, gneissic conglomerate, and limestone. At Dalmore the right bank of the Thurso is composed of Boulder-clay, the left of gravel. Here is seen a chain of moraines, composed of granitic gravel and sand. At Tormsdale a vein of some cinder-like material occurs. The flagstones at Poll a' Chreagan are covered with freestone, as also at Dale Bridge on the right bank of the river. On the left the flags lie exposed in great tabular masses, overlying limestone. At the top of the Mill Pool are the remains of a natural dam. Below this pool a band of freestone once crossed the bed of the river. At Dale are shifting beds of gravel, and here the river is continually changing it course. Below Polihour flags again appear, and opposite Scots Calder are banks of Boulder-clay, the boulders therein being very distinctly striated. Great masses of flagstone block up the bed of the stream at Gerston. At Halkirk the cliffs are coated with red ochre.

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[1] Rep. Brit. Assoc. (Montreal Meeting, 1884), Transactions of Sections C and E.

Granite is not visible at Dorrery, as has been stated by at least one writer, but it does not appear to lie at any great depth below the flags.

At Achanarras a curious fossil fish, *Coccosteus*, is found in a small slate quarry.

East from Spittal the angle at which the rocks dip gradually diminishes, and at Lanergill reaches its nearest approach to a dead level.

Drift gravel prevails in the neighbourhood of Halsary, and also down part of Strathberg, where the banks of the ancient river may again be traced. Here the Dalmore moraines are continued.

No evidence of volcanic action can be gathered from an examination of the rocks of Central Caithness, but the district presents a fair field for the study of erosion by ice, air, and water.

V.—ON THE WATERWORKS AT GOLDSTONE ROAD, BRIGHTON.

By W. WHITAKER, B.A., F.G.S., Assoc Inst.C.E.

NOTES of a visit underground in December 1884, when the water was pumped down for extending the galleries. These works are perhaps the best example of the right way of getting a very large supply of water from the Chalk, galleries being driven (in one case to the length of 800 feet) at about low-water level, so as to cut the fissures and intercept the water on its way to the sea.

The whole of the works (shafts and galleries) are in the White Chalk, with but few flints in the bedding-planes, but with many oblique layers along joint-planes. The supply comes chiefly from a few powerful springs, and, though small contributions issue between these, it is noteworthy how far a tunnel has sometimes been driven before reaching a fissure of large yield. Under these circumstances borings, or even shafts, might have failed to yield a large supply.

The roof of the north-eastern gallery is throughout of one bed, rarely needing support, a thin brittle layer of flint at its base being cleared away.

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VI.—ON SOME ROCK SPECIMENS FROM THE ISLANDS OF THE FERNANDO NORONHA GROUP.

By Professor A. RENARD, LL.D.

THE rock specimens described in this communication were collected by J. G. Buchanan, Esq., during the voyage of the "Challenger." The islands have been described by Darwin in his "Geological Observations on Volcanic Islands" (2nd edition, p. 27). The author, after having explained the geological structure, gives lithological descriptions of the chief types of the rocks, which may be referred to the phonolites (St. Michael's Mount). These phonolites are composed of sanidine, augite, nepheline, hornblende, magnetite, nosean, and titanite.

The rocks of Rat Island are basalts with nepheline. The constituent minerals are augite and olivine. The ground-mass is almost entirely composed of nepheline; biotite and apatite occur as accessory constituents. The little island known as Platform Island is also basaltic, with a doleritic texture. It is composed of labradorite, augite, olivine, magnetite, and biotite. The rock has undergone alterations.

VII.—TRACES OF EARLY HUMAN HABITATIONS ON DEESIDE & VICINITY.

By the Rev. J. G. MICHIE, A.M.

CIRCULAR CAIRNS:—Their structure. Their probable uses—human dwellings; sepulchral purposes. Urns, chests (cists) found in connection (Migvie).

YERD HOUSES:—General structure—examples in Cromer, Glenkindy, and Kildrummy. Probable uses. Generally found in the vicinity of round cairns and circular foundations.

LAKE DWELLINGS (Crannogs):—Island in Lock Kinnord, Loch of Leys. Similar to those found in Wigtonshire and Ayrshire. Dr. Stuart's "Scottish Crannogs," and Dr. Munroe's "Ancient Scottish Lake Dwellings." Relics found in connection—canoes, arrow-heads, celts, stone knives, and stone cups.

MOATED FORTS:—Lumphanan, Invernochty, Rothiemurchus, and ruder form at Loch Davan.

ANCIENT PICTISH TOWNS:—Character and situation. DAVAN—Short description of; probably the *Devana* of the Romans.

REVIEWS.

I.—FÖRTECKNING PÅ GOTLANDS SILURISKA CRUSTACÉER. Af G. LINDSTRÖM. Tafl. xii.–xvi. (Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1885, No. 6. Stockholm.)

A CATALOGUE OF THE SILURIAN CRUSTACEA OF GOTLAND. By G. LINDSTRÖM. 8vo. pp. 63, 5 Plates.

IN the thirty years which have elapsed since the issue of Angelin's great work "Palæontologica Scandinavica," there has been a great accumulation of fresh fossil material from Swedish strata, partly through the labours of Angelin himself, and partly through the work of succeeding palæontologists; and Prof. Lindström has undertaken the desirable task of investigating its character. This memoir contains the results of his studies of the Silurian Crustacea of Gotland, from which locality 70 species of Trilobites, and two of Merostomata, are enumerated and described. New species belonging to the following genera are introduced, viz. *Phacops* (1); *Cheirurus* (1); *Sphærexochus* (2); *Lichas* (6); *Harpes* (1); *Calymene* (5); *Phaëtonides* (2); *Cyphaspis* (1); *Proetus* (6); *Illænus* (2); and *Bronteus* (3). A new genus, *Youngia*, based on the characters of *Cheirurus trispinosus*, Young, is formed, and includes two new species. Most of the forms are fragmentary, but the portions preserved retain their surface characters so perfectly, and these have been so clearly and exactly described and figured in the plates and woodcuts, that there should be no difficulty in identifying them. Prof. Lindström gives a table showing the distribution of the species in the four divisions of the Gotland strata, which correspond respectively to our Upper Llandovery, Wenlock Shale, Wenlock Limestone, and Ludlow beds; and from this it appears that in Gotland the Wenlock Limestone is the richest in species; that there are three species peculiar to the Upper Llandovery, ten to the Wenlock Shale, eleven to the Wenlock Limestone, and four to the Ludlow beds. Some species, as *Sphærexochus scabridus*, *Encrinurus punctatus*, and *Illænus barriensis*, appear in all the divisions, whilst all the species of *Lichas* are limited to the two upper divisions. Prof. Lindström further states the noteworthy fact that not one of these species is found in the strata below the marly shales, which are the equivalents of the Upper Llandovery, in Sweden. *Calymene Blumenbachii* has been reported to occur in underlying beds, but according to Lindström, the head-shields attributed to this species, found in West Gotland and in Dalecarlia, are too badly preserved to admit of satisfactory recognition.

G. J. H.

II.—ATLAS VON CHINA. Orographische und Geologische Karten; von FERDINAND FREIHERR VON RICHTHOFEN, zu des Verfassers Werk: China, ergebnisse eigener Reisen und darauf gegründeter Studien. Erste Abtheilung: Das Nördliche China. Berlin, Dietrich Reimer, 1885.

ATLAS OF CHINA. Orographic and Geological Maps, by FERDINAND FREIHERR VON RICHTHOFEN, for the Author's work on China. First part, Northern China.

THE construction of a series of geological maps of such a vast and comparatively unknown country as China, must be a difficult and arduous task, even in the hands of such a competent geologist as Prof. von Richthofen. And yet in this Atlas we have, in addition to the orographical maps, thirteen large maps, each representing an area of 78,000 square kilomètres, on which the boundaries of the principal geological divisions of Northern China are delineated with great apparent precision! The basis of the work rests on the author's observations during his travels in the country, but these of course were limited to the comparatively narrow strip of territory bounding his route; he has further combined the information obtained from other travellers and from the natives; but even so the mapping of the geological features of no small proportion of the country must have depended upon bold generalizations. Whatever may be the result of subsequent actual investigation by future Chinese or European geologists, this preliminary attempt to lay down the geological boundaries of this vast area cannot fail to be of great advantage and assistance to later workers, and deserves the warmest recognition. The maps are on the scale of 1 : 750,000; the colouring employed for the different geological divisions is partly similar to that adopted by the Geological Congress. This first part of the Atlas is intended to accompany the second volume of the author's great work on China, which has been already noticed in the GEOLOGICAL MAGAZINE.[1] G. J. H.

III.—LETHÆA ERRATICA, ODER AUFZÄHLUNG UND BESCHREIBUNG DER IN DER NORDDEUTSCHEN EBENE VORKOMMENDEN DILUVIAL GESCHIEBE NORDISCHER SEDIMENTÄR-GESTEINE. Von FERDINAND RŒMER. Mit 11 Tafeln und 3 Holzschnitten. Palæontologische Abhandlungen herausgegeben von W. DAMES und E. KAYSER. Zweiter Band. Heft 5. (Berlin: G. Reimer, 1885.)

LETHÆA ERRATICA, OR AN ENUMERATION AND DESCRIPTION OF THE DILUVIAL ERRATICS OF NORTHERN SEDIMENTARY ROCKS OCCURRING IN THE PLAINS OF NORTH GERMANY. By FERDINAND RŒMER. 4to. pp. 173. With 11 lithographed plates and 3 woodcuts.

IN the Boulder-clay which is so extensively distributed over the plains of North Germany and Russian Poland, besides the fragments of gneiss, granite, and other crystalline rocks, there are numerous broken-up portions of sedimentary strata, many of which abound in fossils. These fossiliferous erratics have long been studied by German palæontologists, more particularly by the veteran author of this work, and the present memoir, with its 11 lithographed plates of the principal fossils occurring in the Boulder-clay, is intended as a more complete description of them than that published by him in 1862.[2]

The author first gives a list of the principal memoirs which have appeared on the subject since 1828, and then refers briefly to the geological position of the Boulder-clay; the state of preservation of the boulders and fossils; the geographical extension of the deposit; the different formations to which the erratics belong; the original localities from whence they come; and the manner in which they have been transported to their present positions. Following this, is a detailed description of the different species of fossils, of the present distribution of each in the Boulder-clay, and of the beds in which the fossils now occur in other European areas.

The fossiliferous erratics belong to the Cambrian, Silurian, Devonian, Jurassic, Cretaceous, and Tertiary formations. The most abundant and widely distributed are boulders of limestone of Silurian age, belonging to what is known as the Orthoceren-Kalk, the Korallen-Kalk, and the Beyrichien-Kalk. The Silurian and Cambrian erratics have been brought partly from Sweden and partly from the Russian Baltic provinces. Boulders of Devonian age are rare, and limited to the eastern provinces of Prussia; they have undoubtedly been derived from Livonia and Courland. Only a few scattered fragments of Carboniferous and Permian rocks have been met with, and their original localities are unknown; whilst Triassic boulders appear to be entirely absent. Jurassic boulders are only met with in the Eastern half of the Boulder-clay area, as far as the Elbe. Their source is unknown, but they are most nearly related to Jurassic strata in Courland. Cretaceous boulders extend over the entire area; they belong both to the Cenomanian, Turonian, and Senonian divisions; the most abundant are flints, probably derived from the Chalk of Denmark and the South of Sweden. No erratics are known from the Gault and the Neocomian; but calcareous fragments of Wealden age are met with in Brandenburg. These, however, do not correspond with the Wealden strata of N.W. Germany, and their origin is unknown. Tertiary erratics are rare and of limited distribution, but fossil wood and amber are widely scattered in the Boulder-clay.

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[1] Decade II. Vol. IX. p. 429.

[2] Zeitschrift der deutschen geologischen Gesellschaft, bd. 14, pp. 575.

The direction in which the erratics have travelled is partly from North to South, and partly from North-east to South-west. There is no indication of any movement from N.W. to S.E., and no erratics from Norway are met with in the Boulder-clay of Germany. The author believes that the Boulder-clay has been distributed by floating ice, a view which is opposed to that held by the large majority of recent investigators of the subject, who maintain that it is due to the direct action of glacial or inland ice. G. J. H.

REPORTS AND PROCEEDINGS.

I.—Linnean Society of London.

November 5, 1885.—Sir John Lubbock, Bart., M.P., F.R.S., President, in the chair.

The first part of an exhaustive Monograph "On Recent Brachiopoda," accompanied by illustrations, by the late Dr. Thomas Davidson, F.R.S., etc., was read by the Secretary. In this the author reviews the labours of his predecessors in the same field, with regard to the shell, the anatomy of the adult animal, and its embryology. As regards the perplexing question of affinities, he remarks:—"Now, although I do not admit the Brachiopoda to be Worms, they, as well as the Mollusca and some other groups of Invertebrates, may have originally diverged from an ancestral vermiform stem, such as the remarkable worm-like mollusc, *Neomenia*, would denote." He lays stress on the Brachiopodous individual being the product of a single ovum, and not giving rise to others by gemmation. He considers that the shell, the pallial lobes, the intestine, the nerves, and the atrial system afford characters amply sufficient to define the class. The greatest depth at which a living species has been found alive has been 2990 fathoms. As to classification, he groups the recent species into two great divisions: I. *Anthropomata* (Owen) = *Clistenterata* (King); II. *Lypomata* (Owen) = *Tretenterata* (King). The *Anthropomata* he divides into three families:—(1), *Terebratulacea*, with seven subfamilies and thirteen genera and subgenera, seventy species, and twenty-one uncertain species; (2), *Thecideidæ*, with one genus and two species; (3), *Rhynchonellidæ*, one genus, one subgenus, and eight species. The *Lypomata* he also divides into three families, five genera and subgenera, twenty-three species, and seven uncertain species:—(1), *Craniidæ*, with one genus and four species; (2), *Discinidæ*, with one genus, one subgenus, and eight species; (3), *Lingulidæ*, with one genus, one subgenus, and eleven species. He does not accept M. Deslongchamps' scheme (1884) of classifying the *Terebratulina*, bringing forward Mr. Dall's observations on *Waldheimia floridana* of delicate spiculæ in the floor of the great sinuses as telling evidence against the arrangement. The various genera and species are then dealt with, followed by remarks on the *Terebratulaceæ*, with copious descriptions and observations.

II.—Reading Literary and Scientific Society, Oct. 13, 1885.

"On the Coal-fields of the United Kingdom." Inaugural Address from the President, J. H. Blake, F.G.S., Associate Mining Institute C.E., of H. M. Geological Survey of England.

The President remarked that the question as to the rapid exhaustion or otherwise of our coal-fields was of national interest and importance. Coal consists of indurated or mineralized vegetable matter, and occurs in seams, interstratified in beds of sandstone, grit, shale, clay, and ironstone, and more rarely of limestone. These together are called the Coal-measures, which in some Coal-fields attain a thickness of some thousand feet. Of the amount of vegetation required to form not only one seam but forty or fifty or more, varying from one inch to several feet in thickness, which often succeed each other in Coal-fields, we can form no adequate conception, any more than we can calculate the time required for their growth and consolidation. Passing more or less through the stage of peat, each bed or mass of vegetation got buried under successive sediments, and through the influence of time, water, chemical changes and pressure eventually became converted into coal. In Britain and elsewhere the Carboniferous rocks, which were originally more or less horizontal, were disturbed and thrown into a series of wave-like curves or contortions together with other formations of older date. After this disturbance, combined with faults or dislocations of the beds, denudation or waste ensued, and the upper part of the curves being most exposed were in many instances removed or worn away, the portion so removed supplying material for newer strata. The lower part of the curves, or basin-shaped portions, were preserved from destruction by their position. During and after this waste of Carboniferous rocks the Permian and other newer strata were deposited on the eroded edges of the Carboniferous and other older strata, and these in their turn also underwent disturbances in Britain in a minor degree followed by denudation. Thus the Permian and other newer strata lie unconformably on the Carboniferous and other older rocks. It is sometimes possible to estimate approximately and sometimes with certainty the area occupied by Coal-measures under the overlying Permian and Secondary formations, by giving attention to the "strike" and "dip" or inclination of the beds and by other means; and even to infer the basin-shaped form of a Coal-field, part of which is concealed. It was by paying careful attention to physical phenomena such as these and to details of stratification, the thickening and thinning of the formations, their conformity and unconformity, the occurrence of faults or dislocations and other disturbances, that the Committee appointed by the Royal Commission were enabled to estimate the amount of coal, namely, 56,273 millions of tons, which probably exists at workable depths under the Permian, New Red Sandstone and other superincumbent strata in the United Kingdom. Of these 56,273 millions of tons, upwards of 23,000 millions were estimated to occur under Yorkshire, and the remainder in varying proportions from 33 millions in one locality to upwards of 5000 millions in another, under Warwickshire, Leicestershire, Staffordshire, Denbighshire, Cheshire, Lancashire and a few other places in England, and 27 millions in Ireland. In estimating the quantity of available coal in the Coal-fields of the United Kingdom, the depth of 4000 feet was adopted by the Royal Commission as the limit of practical working, and all seams or beds of less than one foot in thickness were excluded from the returns. Having alluded at length to the description of the Coal-fields of the United Kingdom, showing approximately the probable quantity of available or workable coal they contain, the lecturer summed up the calculations as follows:—Wales 34,466 millions of tons, England 45,741 millions of tons, Scotland 9845 millions of tons, and Ireland 155 millions of tons, a grand total of 90,207 millions of tons. To this must be added the 56,273 millions of tons estimated to exist at workable depths under the Permian, New Red Sandstone and other superincumbent strata, making an aggregate of 146,480 millions of tons. From 1870 to 1884—fifteen years—nearly 2052 millions of tons have been produced in this kingdom. Mr. Godwin-Austen had shown that Coal-measures, which thin out under the Chalk near Therouanne, probably set in again near Calais, and are prolonged in the line of the Thames Valley, parallel with the North Downs, and, continuing thence under the valley of the Kennet, extend to the Bath and Bristol Coal area. He showed upon theoretical grounds that the Coal-measures of a large portion of England, France, and Belgium were once continuous, and that the present Coal-fields were merely fragments of the great original deposit preserved in hollows. These views, the lecturer continued, are supported by many eminent geologists who gave evidence before the Commission, but they did not receive the support of Sir Roderick Murchison. The question of coal being deposited in the South of England is still a theory. Turning to the question of the duration of the total available quantity, the lecturer said that chiefly depended upon the statistics of consumption. In the year 1660 the coal produce of the United Kingdom was apparently only about 2¼ millions of tons; in 1700 a little more than 2½ millions; in 1750 nearly 5 millions; in 1800 upwards of 10 millions of tons. About this period the system of canal navigation was rapidly extended, and the result was that coals were gradually finding their way into new districts, by which means the consumption of coal was greatly increased. In 1816 the production reached probably 27 millions. Advancing to a later period when coal statistics were more carefully collected, it appears that in 1854 the production of coal was upwards of 64 millions. From that period up to and including 1883, when the production of coal in the United Kingdom reached the largest quantity yet recorded, namely, nearly 163¾ millions of tons, there has been a progressive increase; except in the years 1857, 1858, 1874 and 1878, on which occasions there was a decrease varying from about one to two millions as compared with the quantity raised in the year immediately preceding these dates. Again last year (1884) there was a decrease of nearly three millions of tons. Whatever view may be taken of the question of the duration of coal, the results will be subject to contingencies. On the one hand, the rate of consumption may be thrown back to any extent by adverse causes affecting our national prosperity, and on the other hand, new discoveries and developments in new directions may arise to produce a contrary effect upon the consumption of coal. Every hypothesis must be speculative, but it is certain that if the present rate of increase in the consumption of coal be indefinitely continued even in an approximate degree, the progress towards the exhaustion of our coal will be very rapid.—From the *Reading Observer*, Oct. 17, 1885.

III.—Geological Society of London.

(1.)—Nov. 18, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "Results of Recent Researches in some Bone-caves in North Wales (Ffynnon Beuno and Cae Gwyn)." By Henry Hicks, M.D, F.R.S., F.G.S., with Notes on the Animal Remains, by W. Davies, Esq., F.G.S., of the British Museum (Natural History).

This paper contained the results of researches carried on in these caverns in the summers of 1883, 1884, and 1885 by Mr. E. Bouverie Luxmore, of St. Asaph, and the author. The enormous collection of bones belonging to the now extinct animals of Pleistocene age obtained had been submitted for examination to Mr. W. Davies, and afterwards distributed to various museums. Several well-worked flint implements were also discovered in association with the bones.

The following are the conclusions arrived at by the author, from the facts obtained during the explorations:—That abundant evidence has been furnished to show that the caverns had been occupied by hyænas, and possibly by other beasts of prey, as dens, into which portions of carcasses of various animals had been conveyed in Pleistocene times. The very great abundance of some animals, such as the rhinoceros, horse and reindeer, and the frequent presence of bones belonging to young animals, proved that the plain of the Vale of Clwyd, with that extending northward under the Irish Sea, must have formed a favourite feeding-ground even at that time. The flint implements and worked bones showed also that man was contemporary with these animals. The facts perhaps, however, of greatest importance, made out during these researches, are those which bear on some questions of physical geology in regard to this area, which hitherto have been shrouded more or less in doubt. The views on the physical conditions in Pleistocene times of the areas in North Wales in which these and the other bone-caverns occur, so ably put forward by Sir A. C. Ramsay, appeared to the author to be strongly supported by the results obtained in these explorations. The ravine in which the caverns occur must have been scooped out previous to the deposition in it of the glacial sands and Boulder-clays. This sand and clay, there seems good evidence to show, must have filled up the ravine to a height above the entrances to the caverns, and such sands and clays are now found at some points to completely fill up the caverns. How, then, did these sands and clays get into the caverns? Were they forced in through the entrances by marine action or by a glacier filling the valley? Or were they conveyed in subsequent to the deposition of the Boulder-clay in the valley and surrounding area? The position of the caverns in an escarpment of limestone, at the end of a ridge of these rocks, with a sharp fall on either side, prohibits the idea that the material could have been washed in from the higher ground, as has been suggested by some in the case of other caverns, if it had anything like its present configuration. Moreover, there is scarcely any deposit now visible upon the limestone ridge, and there is no certainty that there ever was deposited there any great thickness of such a clay as that now found in the caverns. The general position also of the bones in some of the tunnels seems to indicate clearly that the force which broke up the stalagmite floor, in some places 10–12 inches thick, and stalactites 6 to 8 inches across, which thrust many of the large and heavy bones into fissures high up in the caverns and placed them at all angles in the deposit, and must have acted from the entrance inwards, and the only force which seems to meets these conditions is marine action. The following seem to the author to be the changes indicated by the deposits. The lowest in the caverns, consisting almost entirely of local materials, must have been introduced by a river which flowed in the valley at a very much higher level than does the little stream at present. Gradually, as the valley was being excavated, and the caverns were above the reach of floods, hyænas and other beasts of prey occupied them, and conveyed the remains of other animals into them. Man also must have been present at some part of this period. Gradually the land became depressed, the animals disappeared, stalagmite was formed, and the sea at last entered the caverns, filling them up with sand and pebbles, and burying also the remains not washed out. Floating ice deposited in this sea the fragments of rocks derived from northern sources, and these became mixed with local rocks and clays brought down from surrounding areas. The greater part of the Boulder-clay in the Vale of Clwyd was probably deposited as the land was being raised out of this Mid-Glacial sea. During the process of elevation the caverns became again disturbed by marine action and the upper fine reddish loam and the laminated clays were deposited. It seemed to the author impossible to avoid the conclusion that these caverns must have been submerged, and afterwards elevated to their present height of about 400 feet above the level of the sea, since they were occupied by Palæolithic man and the Pleistocene animals.

2. "On the Occurrence of the Crocodilian Genus *Tomistoma* in the Miocene of the Maltese Islands." By R. Lydekker, Esq., F.G.S.

The author described the anterior portion of the cranial rostrum of a Crocodilian from the Miocene of Malta, to which Prof. Sir R. Owen has given the MS. name of *Melitosaurus champsoides*. The author considered that there were no characters by which the specimen could be generically distinguished from *Tomistoma*. Mention was made of a second crocodilian skull from the Miocene of the Maltese Islands, and of a third from Lower Austria, both of which the author thought might be included in the same genus.

3. "Description of the Cranium of a new Species of *Erinaceus* from the Upper Miocene of Œningen." By R. Lydekker, Esq., F.G.S.

The author described the palatal half of the cranium of a large species of *Erinaceus* from the Upper Miocene of Œningen, which he regarded as closely allied to the existing *E. europæus*, and proposed to name *E. œningensis*.

(2.)—Dec. 2, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On some Borings in Kent.—A Contribution to the Deep-seated Geology of the London Basin." By W. Whitaker, B.A., F.G.S., Assoc. Inst. C.E. (Communicated by permission of the Director-General of the Geological Survey.)

Seven deep borings in the eastern part of Kent were described, all of them reaching to the Gault. The chief one is at Chatham Dockyard, where after passing through the whole thickness of the Chalk, the Gault was found to be 193 feet thick; whilst the Lower Greensand was only 41 feet, and was underlain by Oxford Clay, a formation not before known in Kent.

These facts involve the thinning of the Lower Greensand from 200 feet at the outcrop a few miles to the south, and the entire loss of the whole of the Wealden Series, which further south exists in great force, the Weald Clay being 600 feet thick, or perhaps more, and the Hastings Beds 700 feet or more.

Still further south, in the central part of the Wealden district, there are outcrops of the Purbeck Beds, whilst the Subwealden boring continues the series downwards. We have thus an addition to the beds wanting at Chatham of some 400 feet of Purbeck and Portlandian, of over 1100 feet of Kimmeridgian, and of nearly 500 ft. of Corallian, etc. In a section of 32 miles, therefore (the distance between the Subwealden and the Chatham borings), we have a thinning of beds to the extent of over 3400 feet, or at the average rate of about 100 feet in a mile.

This northerly thinning agrees with the facts that have been brought before us from other deep borings in and near London; but the Chatham boring is the first in the London Basin in which a Middle Jurassic formation has been found. The teaching of the deep borings, as a whole, is that north of the Thames older rocks rise up beneath the Cretaceous beds, whilst on the south newer rocks come in between the two.

The question of the finding of the Coal-measures beneath parts of the London Basin seems to admit of a hopeful answer, whilst the lesson of the deep borings as regards water-supply is that there is small chance of getting water from the Lower Greensand at great depths underground.

It would be well if underground exploration could be conducted on a systematic plan, with proper regard to both topographical and geological considerations, and not left any longer to the chance work of people in search of water.

2. "Note on some recent openings in the Liassic and Oolitic Rocks of Fawler in Oxfordshire, and on the arrangement of those rocks near Charlbury." By F. A. Bather, Esq. (Communicated by Prof. J. Prestwich, M.A., F.R.S., F.G.S.)

The river Evenlode rises in the Lower Lias of the Vale of Moreton, traverses the range of Oolites, and joins the Isis opposite Wytham Mill. Lias is exposed to about three-quarters of a mile below Fawler, where Great Oolite is brought down by a fault; and in the Geological Survey map Lower Lias is brought down the valley to within half a mile of Charlbury Railway Station.

In this paper the author gives reasons for believing that the distribution of the different beds constituting the Lias in the Evenlode Valley do not agree with the Geological Survey map, nor with Prof. Hull's description, recent sections and borings made for clay, used in brick- and pottery-making, having exposed Lower-Lias clay in a brick-yard at Fawler, marlstone and Upper-Lias clay in a neighbouring coombe, and in a long section 100 yards north of the brick-yard Inferior Oolite comes in upon the Upper-Lias clay. On examining the banks of the Evenlode north of Charlbury, it was found that clays referred to in the Survey map to Lower Lias are really Upper Liassic, being above the Marlstone, sections of which are exposed near Culsham Bridge.

It was shown how these corrections in the mapping of the ground are explained by the section along the line of the Evenlode and by the dips of the beds.

CORRESPONDENCE.

OLD RED SANDSTONE UNDER LONDON.

Sir,—In his paper "On the Nature and Relations of the Jurassic Deposits which Underlie London" (Quart. Journ. Geol. Soc. vol. xl.) Prof. Judd discusses the age of certain red rocks met with deep down at Richmond, Crossness, and at Kentish Town. One question that arose was whether rocks of the barren Old Red Sandstone type and of the Devonian (Eifelian) type were likely to be met with in close proximity. While admitting that, as in the Ardennes, so under London, the lowest member of the Devonian (the Gédinnien of Belgian geologists) may underlie strata of the Eifelian type; yet Prof. Judd attaches much weight to the suggestion made by Mr. Whitaker that rocks of Old Red Sandstone and Devonian type are not likely to occur near together.

This suggestion is, however, opposed to what is well known in Devonshire. There we have the Red Sandstones of Cockington near Torquay, and the grits of Picklecombe and Staddon near Plymouth, as well as the Pickwell Down Sandstones of North Devon, which, as Mr. Champernowne remarks (Proc. Geol. Assoc. vol. viii. p. 469), probably represent (both stratigraphically and lithologically) parts of the Upper Old Red Sandstone. These strata are nowhere far removed, geographically, from rocks of the Eifelian type.

Then, too, we have the Lower Devonian grits of Lincombe, Warberry and Meadfoot in South Devon, possibly equivalent in part to the Hangman grits of North Devon; but they are of a different character from the rocks resembling the Upper Old Red Sandstone. Prof. Prestwich has insisted on the resemblance of the Kentish Town red beds to the (Upper) Old Red Sandstone of the Mendip Hills (Judd, *op. cit.* p. 753).

Hence, without committing myself to any definite opinion on the subject, there appears to me no reason why rocks of Old Red Sandstone type (whether Upper or Lower) should not occur, as well as Devonian strata, under the London Basin. Recent researches, moreover, tend to show that the Devonian (Eifelian) strata may bridge over the interval between the Upper and Lower Old Red Sandstone.

Of course it is still open to question whether these red rocks under London are Upper or Lower Old Red Sandstone, or New Red Sandstone (Poikilitic). Horace B. Woodward.

Bradford-on-Avon, *Nov.* 1885.

THE "FAUNA ANTIQUA SIVALENSIS."

Sir,—As your readers are doubtless aware, the atlas of Falconer and Cautley's "Fauna Antiqua Sivalensis" was originally published in separate parts, with paper covers bearing the date of publication of each part; but as the work was never completed, no general title-page ever appeared. In all copies in public libraries that I have seen the atlas has been bound, and the original paper covers destroyed, so that there is no means of knowing the date of publication of particular plates in which specific names make their first appearance, and I have noticed in several instances that writers have consequently been unable to give the exact date of publication to such names. As I am fortunate enough to possess a copy in which the original covers are preserved, I have thought it well to record the dates of publication of the different parts, and the numbers of the plates contained in each, viz.—

1846.	Part	I.	Plates	1—12.
,,	,,	II.	,,	13—22 and 13 *a* (double).
1847.	„	III.	,,	12 A, 12 B, 12 C, 12 D, 14 A, 14 B, 18 A, 19 A, 20 A, 23, 24, 24 A.
,,	,,	IV.	,,	25—33, and 25 A, 29 A.
,,	,,	V.	,,	34—45.
„	,,	VI.	,,	46—56.
„	,,	VII.	,,	57—68.
,,	,,	VIII.	„	69—80.
1849.	„	IX.	,,	81—92.

The Lodge, Harpenden, Herts. R. Lydekker.

FAUNA OF THE GAS-COAL OF BOHEMIA.

Sir,—In the Geological Magazine for November, 1885, p. 527, Prof. E. D. Cope, in a very kind mention of my work, "Fauna der Gaskohle in d. Kalksteinen d. Permformation Böhmens," Prag, 1885, asks why I do not agree with him that *Cricotus* had the thoracic vertebræ embolomerous. Having only had the opportunity of comparing the figure of *Cricotus*, which I have reproduced on p. 4, band ii. heft i., I saw only the neural arches and the ribs, and on the lumbar vertebræ some bodies which I was inclined to consider elements of rachitomous structure. I feel sure that in the rich material in Prof. Cope's hands he has evidence in support of his opinion that all the vertebræ in *Cricotus* are embolomerous in structure.

Prague, 3 *Nov.*, 1885. Dr. Anton Fritsch.

ON SOME CRETACEOUS MADREPORARIA, BY MR. R. F. TOMES, F.G.S.

Sir,—As Referee of the paper by Mr. R. F. Tomes 'On some imperfectly known Madreporaria from the Cretaceous Formation of England,' which was withdrawn by the Author from the Geological Society, and is printed in the Geological Magazine for December, 1885, p. 541, Pl. XIV. I take exception to the statement in brackets in the concluding paragraph of the paper on p. 552, "It is now printed verbatim with figures by Mr. C. Berjeau of the specimens exhibited at that meeting," as calculated to mislead. It is true that the originals of *some* of the figures on the Plate accompanying the paper were exhibited at the Meeting, but the original specimens of Figs. 1, 2, 3, 4, 5, 6, were not shown on that occasion. Further, in the Explanation of the Plate on p. 552, it is stated: "Fig. 7. *Rhizangia mamilliformis*. Three corallites united by the stolon." Fig. 8. *Ib.* Two corallites similarly united." In the originals, however, which were exhibited at the Meeting, the corallites were *not* united by the stolon, and they are not figured as united (in Plate XIV. Figs. 7, 8) in the GEOLOGICAL MAGAZINE, though they were so in the original drawing submitted to the Geological Society by Mr. Tomes.

As these statements relate to matters of fact, I should feel obliged if you would allow me this opportunity of rectifying them in the MAGAZINE.

"THE REFEREE."

MISCELLANEOUS.

THE "COMING-OF-AGE" OF THE GEOLOGICAL MAGAZINE.

TESTIMONIAL TO THE EDITOR, DR. H. WOODWARD, F.R.S., F.G.S.

A meeting of the Subscribers to the Testimonial to Dr. H. Woodward, F.R.S., for twenty-one years Editor of the GEOLOGICAL MAGAZINE, was held on the 15th December, 1885, at the Apartments of the Geological Society, Burlington House, when Prof. T. G. Bonney, F.R.S. (President Geol. Soc.), presented to that gentleman, on behalf of the subscribers, a silver salver with a tea and coffee service and a cheque for £253. On making the presentation, Prof. Bonney addressed Dr. Woodward as follows:—

"DR. WOODWARD—

It is now rather more than twenty-one years since the GEOLOGICAL MAGAZINE arose upon the foundation—I had almost said the ruins—of an earlier publication. For the whole of that time you have been one of its editors, for almost the whole its principal editor. On you, though supported by the aid and counsel of most able coadjutors, has fallen the chief burden of the work, the chief responsibility of the undertaking.

It would be difficult to appreciate too highly the aid which the GEOLOGICAL MAGAZINE has rendered to the progress of our Science. It has supplied a want which had long been felt, which would at once recur if it ceased to make its welcome monthly appearance. There are many Geological notes and papers written, which, from their brevity, from their interest being of a somewhat ephemeral character, from their treatment being more historical or their aim more controversial, are not exactly suited to the pages of the Quarterly Journal of the Society in whose rooms we are assembled; yet the appearance of these in print is a boon to students and a benefit to science. The GEOLOGICAL MAGAZINE thus occupies a position, which, on one hand, has common ground with our Quarterly Journal; on another, with the Proceedings of Local Scientific Societies; on a third with such a publication as "Nature," but which is not exactly covered by any one of these. During all these years it has been an important aid to British Geologists, and

I do but echo their sentiments when I wish it and its editor a long and prosperous life.

But this, Dr. Woodward, is not the only service that you have rendered to science. It is possible for an editor to nip early aspirations in the bud and to petrify the neophyte in science by a cold breath of disapproval or sarcasm. All, however, who, like myself, have made in the pages of the GEOLOGICAL MAGAZINE their first venture in scientific authorship, will be ready to testify to the kind welcome and friendly encouragement which we received from you. Many, I feel sure, have thus been animated to further efforts; so that you may with just pride assert that under your auspices the GEOLOGICAL MAGAZINE has enlisted many recruits for the great army of scientific workers. Yet more, not only in its pages, but also at your place in the British Museum, you have been ever ready to help the student, and to place at his disposal, with unvarying kindness and courtesy, the full stores of your ripe knowledge. This work, so far as the GEOLOGICAL MAGAZINE is concerned, you have done, in reality, if not in name, at your own cost. The small sum assigned to you as Editor—inadequate at the best as a return for your labours, has frequently been consumed by expenses which you have incurred to increase—I had almost said to maintain—its efficiency. In this wealthy country those who labour on behalf of science, especially in regard to its literature, must generally be content to do it at their own cost. You have done this ungrudgingly for so long a time, though, as the chief bread-winner of a family, you might justly have excused yourself from so unremunerative a task.

The sum of money which, on behalf of the Subscribers, I have the pleasure of placing in your hands is no discharge of the debt which is due to you from Geologists, but it may suffice to prevent you from feeling that the members of your household have been serious losers by your zeal for the progress of Science; and in asking you to accept this small present of plate, your friends, for whom I speak, wish to leave with you a more visible memorial of their respect and regard. They trust it will remind yourself and the helpmate who has shared your labours—remind you both, we trust, for many years to come—that we were not wholly ungrateful. But, even when the call to cease from work has sounded for those chiefly interested in the friendly gathering of to-day, this little memorial may avail to show your children how much their father was esteemed, and may nerve them to emulate the example of their parents."

Dr. Woodward in reply said:—

"PROF. BONNEY AND GENTLEMEN—

Words are but feeble vehicles in which to convey the warm feelings that rise in my mind to-day, and strive for utterance in response to the eloquent eulogium you have just delivered; and when I look at the munificent testimonial you have presented to me, I am at a loss to conceive how my poor exertions as Editor of the GEOLOGICAL MAGAZINE can have been deemed worthy of so high a recognition.

Of one thing I feel assured that I owe very much to the kind words which you, Sir, expressed from this chair in reference to myself in your Presidential address in February last, and I am grateful to learn how large a number of my friends have inscribed their names to this very handsome gift, which will be to me a lasting token of their regard and friendship, and for my children after me.

The Geological Magazine is not by any means the earliest periodical specially devoted to geology, although it may very justly claim to have survived for a longer period than either of its predecessors.

The first attempt was made by Mr. Edward Charlesworth, F.G.S., who commenced "The London Geological Journal" in September, 1846. Three very excellent and richly illustrated Numbers appeared in September, 1846, and February and May, 1847, when it expired—probably from want of funds. The veteran Editor still survives, and so also do three of his contributors, Prof. Morris, Mr. James Carter of Cambridge, and Mr. William Cunnington, F.G.S., formerly of Devizes, Wilts.

The "Geologist," edited by Mr. S. J. Mackie, was commenced in 1858, and after five years and a half was merged (by purchase) in the Geological Magazine in July, 1864.

It is pleasant to observe amongst the contributors to the *first* volume of the "Geologist" in 1858, the names of the Rev. P. B. Brodie, Prof. J. Morris, Prof. Rupert Jones, Prof. (Sir) A. C. Ramsay, and Prof. Prestwich, names still prominent on the "roll-call" of eminent *living* geologists.

It is gratifying to know that for the past 21 years I have carried with me so large and influential a body of supporters, both at home and abroad.

But of the friends who stood beside us at the outset of our enterprise, many have, alas! left us and "gone with the great departed into the Silent Land."

I rejoice, however, that Sir Richard Owen, Sir A. C. Ramsay, Dr. A. Geikie, Professors Huxley, Prestwich, Rupert Jones, Morris, Boyd Dawkins, Ruskin, Edward Hull, H. G. Seeley, Bonney, Nicholson, Dr. John Evans, Mr. Etheridge, Mr. Topley, Mr. H. M. Jenkins, Mr. Kinahan, Mr. Meyer and many others amongst my first contributors, are still with us; nor have we lacked very many new and able friends who have helped us through what may be termed the "renaissance period," or middle-age of our existence, and have continued to stand by us manfully until the present day.

Glancing for a moment at the period embraced by the joint volumes of the "Geologist" and the Geological Magazine combined (*i.e.* 28 years), we have witnessed in that quarter of a century some of the greatest advances which have ever been made in our science.

The dissemination of the Darwinian theory of Evolution has made the long-buried past of Geological history only an early chapter in the life of our earth, and Palæontology and Zoology have clasped hands never to be again disassociated.

The past quarter-century has also revealed to us that wonderful chapter in the History of Early Man as displayed in the Old River Valley Gravels, Brickearths, and Peat Deposits, in the Bone-caves, Rock-shelters, Kitchen-middens, Lake-dwellings, and other Quaternary records of our Race, bringing into prominence the latest chapter of Geology which 'dovetails' the 'prehistoric' with the 'historic' periods.

The time would fail to tell of the progress of our science in a better knowledge of Physiography, of "Climate and Time," the "Great Ice-Age," the Study of Earthquakes and Volcanoes; the Depths of the Sea; the Formation of Mountain Chains; of Metamorphism; Atmospheric Denudation; of the Continuity of Matter. Lastly, but most important, both for organic and inorganic studies, has been the grand development of Microscopic research as applied both to Palæontological and Mineralogical studies, with which the names of our past President H. C. Sorby, and our present President Prof. Bonney, will always be associated, and for which the Royal Microscopical Society and Mr. Frank Crisp have laboured energetically and long.

Probably no better sign of the utility of the GEOLOGICAL MAGAZINE could be given than the fact of the abundant supply of materials to fill its pages which the Editor receives.

Having started the present serial in 1864, it is very agreeable to be able to state that after the first year, during which my friend Prof. Rupert Jones undertook (at Messrs. Longmans' request) the task of Chief Editor—I have had the sole charge of the GEOLOGICAL MAGAZINE and have passed each number through the press myself, nor have I relegated the duty to other hands on a single occasion.

Like other ephemerides, the GEOLOGICAL MAGAZINE has had its periods of financial depression. At 18 months it was given over for dead by its first publishers (Messrs. Longmans & Co.), and again at 10 years old it hardly seemed likely to pull through, and Messrs. Trübner & Co. were rather doubtful as to the advisability of letting it go on; but thanks to the generous support of friends, it recovered from both crises and has still, I trust, the promise of many years of usefulness before it.

Having arranged its contents month by month for so many years, with my own hands, I have sometimes imagined it to be all my own; but it would indeed be a miserable failure were it not for the long list of distinguished contributors whose papers give value to its pages, and without whom the GEOLOGICAL MAGAZINE would years ago have ceased to exist.

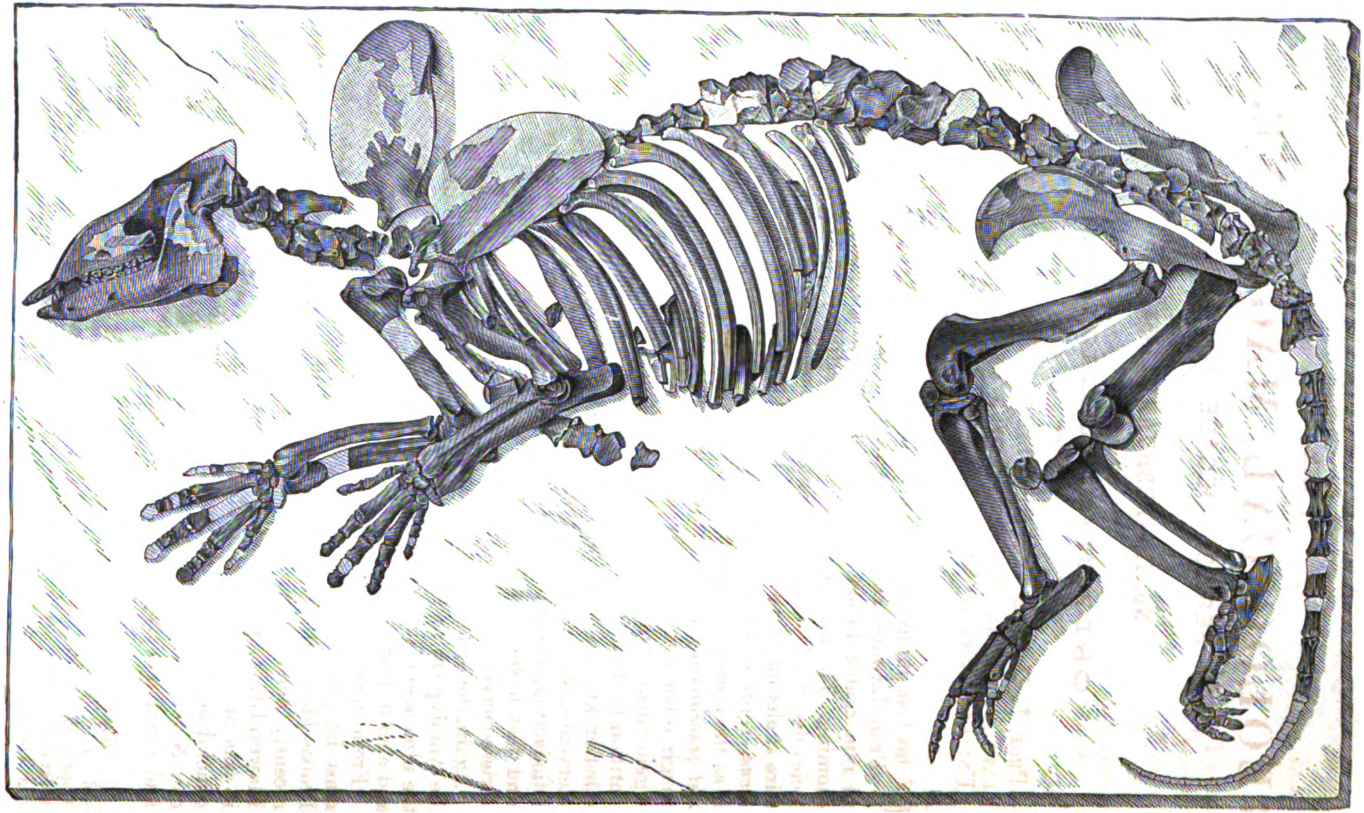
As regards its financial position, the GEOLOGICAL MAGAZINE has the disadvantage of being a Class-periodical — appealing only to Geologists, Palæontologists, and Mineralogists.

The "Annals and Magazine" and "Silliman's Journal" have much broader bases, taking cognizance of all branches of Natural History, and, in the case of Silliman, of Chemistry and Astronomy also.

But notwithstanding our limited sphere, we have been able to sustain life for 21 years, and *a few degrees of warmth* on the part of our geological friends, in adding to our list of subscribers, would produce a marvellous effect in an *increased circulation*, gratifying alike to Publishers, Printers, Artists and Editor, who have done their best to keep the production of the GEOLOGICAL MAGAZINE up to the standard of the present time.

If any stimulus were needed by myself as Editor, my friends have this day applied it in the form of a very substantial recognition of my services, for which I am bound to reiterate my warmest and most sincere thanks. I trust, Sir, that you will long continue, with my other friends, to give me that kindly aid and support which is so essential to the future success of the GEOLOGICAL MAGAZINE.

WORK ON BRITISH PETROGRAPHY.—Messrs. Watson Bros. and Douglas, of Birmingham, announce the publication of a work on British Petrography, being a Description of the Ordinary Rocks of the British Isles, by J. J. Harris Teall, M.A., F.G.S., etc., illustrated by 50 Chromo-Lithographic plates from original drawings of typical microscopic slides. To be completed in 25 Imperial Octavo Monthly parts, including 100 figures and about 350 pages of text. The first part is announced to be published in February next. From a previous acquaintance with Mr. Teall's able and careful labours in petrography, we anticipate that this work will be a most valuable Book of Reference for the use of Professors and Lecturers in Geology and Petrography, and for all who are interested in the study of British Rocks.



Skeleton of Phenacodus primævus, Cope,

Wasatch Eocene, Big-Horn Basin, Northern Wyoming, U. S. N. America.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. II.—FEBRUARY, 1886.

ORIGINAL ARTICLES.

I.—Prof. E. D. Cope, on a New Type of Perissodactyle Ungulate from the Wasatch Eocene of Wyoming Territory, United States of North America.

(PLATE II.)

IN his last published volume on the Vertebrata of the Territories,[1] Prof. Edward D. Cope has figured and described many new and remarkable forms of the Order Ungulata from the Eocene of Wyoming. The most important and interesting among the numerous species described being the genus *Phenacodus*, of which the nearly entire skeletons of two species have been discovered, namely *P. primævus*, represented in our plate (Plate II.) and *P. Vortmani*. So far as the present evidence goes, *Phenacodus* appears to have been the *most generalized form* of a Perissodactyle Ungulate hitherto described, though other contemporary genera may ultimately show characters as generalized, when the relation of those species founded upon the dentition to those founded on the detached bones of the extremities is better known. The teeth of *Phenacodus* are tuberculated, with intervening valleys, resembling the dentition of some of the bunodont Artiodactyla, whilst the femur has a third trochanter, and the fore and hind feet have each five well-developed digits, showing it to be a Perissodactyle or odd-toed ungulate.

Again, the scapula is widened anteriorly, as in the Ursine Carnivora, the Amblypoda and Proboscidea. With the last group the form of the ulna also coincides, being large and broad relatively to the radius, and also in that the bones of the carpus do not interlock.

From these coincidences of structure Prof. Cope says, "This genus must be placed in a special group of an order which includes the Proboscidea" (p. 383). On the other hand, in a lecture on the Horse, recently delivered at the City of London Institute, Prof. W. H. Flower, LL.D., F.R.S., infers, from certain structural characters, that it was an early ancestor of the *Equidæ*. However, the following general description of the genus (extracted chiefly from the "American Naturalist,"[2] and reproduced again in Prof. E. D. Cope's later and grander work) will better serve to convey, in the author's own words, the leading facts in reference to this remarkable Eocene Mammal.

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[1] "Report United States Geological Survey of the Territories," F. V. Hayden. vol. iii. "The Vertebrata of the Tertiary Formation of the West," Edward D. Cope. Washington, 1884 (inner title 1883); 4to. pp. xxxiv. and 1009; plates 75, several folding.

[2] The American Naturalist, vol. xv. 1881, p. 1017.

"A NEW TYPE OF PERISSODACTYLE UNGULATE.

In a paper on the 'Homologies and Origin of the Molar Teeth of the Mammalia Educabilia,' published in March, 1874, I ventured the generalization that the primitive types of the Ungulata would be discovered to be characterized by the possession of five-toed plantigrade feet, and tubercular teeth. No Perissodactyle or Artiodactyle mammal was known at that time to possess such feet, nor was any Perissodactyle known to possess tubercular teeth. Shortly after advancing the above hypothesis, I discovered the foot structure of *Coryphodon*, which is five-toed and plantigrade, but the teeth are not of the tubercular type. For this and allied genera, I defined a new order, the Amblypoda, and I have published the confident anticipation that genera would be discovered which should possess tubercular (bunodont) teeth. This prediction has not yet been realized. I now, however, record a discovery, which goes far towards satisfying the generalization first mentioned, and indicates that the realization of the prophecy respecting the Amblypoda is only a question of time.

In 1873 I described, from teeth alone, a genus under the name of *Phenacodus*, and although a good many specimens of the dentition have come into my possession since that date, I have never been able to assign the genus its true position in the mammalian class. The teeth resemble those of suilline Ungulates, but I have never had sufficient evidence to permit its reference to that group. Allied genera recently discovered by me have been stated to have a hog-like dentition, but that their position could not be determined until the structure of the feet shall have been ascertained.

In his recent explorations in the Wasatch Eocene of Wyoming, Mr. J. L. Wortman was fortunate enough to discover a nearly entire skeleton of a *Phenacodus* very near the typical *P. primævus*, which presents all the characters essential to a full determination of its place in the system. The unexpected result is, that this genus must be referred to the order Perissodactyla and the Proboscidea, and that, with its allies, it must form a special division of that order corresponding in the tubercular characters of its teeth with the bunodont or suilline division of the Artiodactyla. In this character, however, there is a closer gradation than in the case of the Artiodactyla, and it would scarcely be necessary to create such a group on that character alone. But the genus differs further from the Perissodactyla and approaches the Proboscidea, in the fact that the astragalus articulates with the navicular only, and by a universally convex surface, as in the Carnivora.

The astragalus resembles that of the latter order very closely, and differs from that of *Hyracotherium* and the nearest forms among the Perissodactyla. *Phenacodus* has, moreover, five well-developed toes on all the feet, and was probably not entirely plantigrade. The cast of the brain-case shows that the cerebral hemispheres were quite small and nearly smooth, and that the very large cerebellum and olfactory lobes were entirely uncovered by them. The bones of the two carpal rows alternate with each other, and there is a third trochanter on the femur. The cervical vertebræ are opisthocœlous. The systematic position of the genus may be schematically represented as follows:

Order PERISSODACTYLA. Ungulate; digits of unequal lengths; carpal bones alternating; a postglenoid process. Astragalus with proximal trochlea, and without distal double ginglymus.

Suborder *Diplarthra.* Astragalus distally plane or concave in one direction, and uniting with both navicular and cuboid bones; a third trochanter on the femur. The known families belonging here.

Suborder *Condylarthra.* Astragalus convex in all directions distally; only uniting with navicular bone; a third trochanter on the femur.

Family *Phenacodontidæ.* Molar teeth tubercular; the premolar teeth different from the molars; five digits on all the feet.

Genera: *Phenacodus,* Cope, and very probably *Catathlæus,*[1] *Mioclænus,* and *Protogonia,*[2] Cope; and perhaps also *Anisonchas,* Cope. These genera include fifteen species, all from the Lower Eocene beds. The Condylarthra are then the ancestral type of the known Perissodactyla, that is, of the Horses, Tapirs, and Rhinoceroses, and of the numerous extinct forms."

Prof. Cope arrives at the following conclusions as to the measurements of the entire animal as figured (see Plate II.). "The measurements of *Phenacodus primævus* show that this species was as large as a 'Big-horn';[3] that its body was rather longer than in that animal, and its legs shorter and more robust. It was in fact proportioned more as in the common American Tapir, but was of smaller size. The middle three toes of both feet reached the ground, whilst the first and fifth projected laterally and posteriorly, like the dew-claws of the Hogs. The tail was longer and heavier than that of any of the living hoofed mammals, resembling in its proportions that of the Wolf. The eyes were small and the muzzle long, but was singularly soft above and near the extremity. Whether this soft part was pierced by valvular muscles, as in the Hippopotamus, or was produced into a short proboscis, as in the Saiga (Antelope) or in the Tapir, cannot be certainly ascertained, but there are indications of the insertion of important cartilages, if not muscles, on the superior faces of the premaxillary bones.

The animal was probably omnivorous in its diet. It was not furnished with any weapons of offence or defence pertaining to the osseous system, so that it must have sought refuge in flight. The well-developed muscular insertion of its limbs, and the digitigrade character of its step, indicate that it may have had considerable speed."

"*Distribution.*—The bones of this species have been found wherever the beds of the Wasatch Epoch occur, but most abundantly in

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[1] American Naturalist, October, 1880.

[2] Proceedings American Philosophical Society, September, 1881.

[3] *Ovis Canadensis,* "The Rocky Mountain Sheep."

Northern Wyoming. From the Wind River Valley Mr. Wortman brought two specimens, and ten from the Big-Horn Basin." (*op. cit.* pp. 462–463).

NOTE.—We are indebted to the kindness of Prof. E. D. Cope for permission to reproduce the figure of *Phenacodus* given in our Pl. II. —EDIT. GEOL. MAG.

II.—AN ANSWER TO "OBSERVATIONS ON SOME IMPERFECTLY KNOWN MADREPORARIA FROM THE CRETACEOUS FORMATION OF ENGLAND, BY R. F. TOMES, ESQ., F.G.S."

By Prof. P. MARTIN DUNCAN, F.R.S.

I HEARD this communication read at the Geological Society in June last, and I made some remarks upon it which are noticed in the Proceedings of the Society. A considerable portion of the paper consisted of criticisms of some of my work which appeared in the British Fossil Corals (2 ser. Pal. Soc. part ii. Nos. 1 and 2, 1869–70). Some specimens were exhibited, in the author's absence, which were presumed to afford evidence of a satisfactory kind. But it was observed that the very imperfect and bad condition of the fossils did not substantiate the author's statements. Many specimens which ought to have been exhibited were not before the Society, and yet the classificatory position of some very rare corals could then and there have been settled. As this paper was not published by the Geological Society, as the author ignores the remarks I made on the paper, and as it appears in the GEOLOGICAL MAGAZINE for December, 1885, p. 541, I ask a small space for a reply.

In answer to Mr. Tomes, I assert that *Micrabacia Fittoni*, nobis (Pal. Soc. *loc. cit.* p. 37, pl. xiv. figs. 6, 7, 8, 9), is not a variety of *Cyclocyathus Fittoni*, Edw. and Haime (Pal. Soc. Brit. Foss. Corals, pt. i. p. 63, pl. xi. figs. 3, 3*a*, 3*b*, 1850). Neither is it that species. The species of *M. Fittoni* was founded upon a solitary yet good specimen, and the drawings of it were good and from nature. Some years after the description of the species, I investigated the morphology of *Micrabacia coronula*, and the results were published (Quart. Journ. Geol. Soc. vol. xl. 1884, p. 561).[1] I pointed out that there was reason to doubt whether *M. Fittoni* was a true *Micrabacia*; but that as the type was not accessible, I did not feel disposed to remove the form until I had an opportunity of investigating it anew. It was, however, not necessary to place the form out of the Fungida, to which section it belongs. I should have been glad to have seen another specimen, but Mr. Tomes did not give me the opportunity, and I am aware that he has not the type. So it is now necessary to compare the form I described with the species with which it is attempted to be associated, namely, *Cyclocyathus Fittoni.*

Amongst the structural details of *Cyclocyathus Fittoni*, Edw. and Haime, is a thin epitheca, and the costæ of the first and second cycles are more prominent than the others; these details are not seen in *M. Fittoni.* The upper or calicular surface is rather convex externally and concave towards the centre, and the fossa is large and well marked, whilst the columella is fasciculate, broad, and papillose at the surface in *Cyclocyathus;* but in *Micrabacia* the corallum is *hemispherical* and there is no large fossa in the entirely convex calice, and the small columella has no papillæ. There are pali and no synapticulæ in *Cyclocyathus,* and there are no pali and many synapticulæ in *Micrabacia.*

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[1] Omitted be to noted by Mr. Tomes.

The student of the Madreporaria who will turn to the figures of the types of the two forms in the Pal. Soc. *loc. cit.* will have no difficulty in recognizing their distinctness. *Cyclocyathus* is an aporose coral, and *Micrabacia* is a true Fungid. Mr. de Wilde drew *M. Fittoni,* nobis, from nature.

Smilotrochus insignis, nobis (Pal. Soc. *loc. cit.* p. 37, pl. xiv. fig. 18, 1870). This is stated by Mr. Tomes to be a *Ceratotrochus.* The morphology of *Smilotrochus* and *Ceratotrochus* was considered in my "Revision of the Genera and Families of the Madreporaria" (Linn. Soc. Journ. Zool. 1884), and it is noticed that *Ceratotrochus* is a *Smilotrochoid* with a columella. The columella of this genus is bundle-shaped and broad (fasciculate),[1] and processes arise from the inner edges of the larger septa and ascend into it and add to its bulk. The top of the columella is papillary and high up in the coral. The specimen with a so-called columella I had not the advantage of seeing, but there is a drawing of it in Mr. Tomes's paper (GEOL. MAG. 1885, Pl. XIV. Fig. 6), and it is evidently a diagram. What is considered to be the columella is not a fasciculate structure gaining processes from the septa, nor is it a spongy columella, but a mass of matrix which always fills up the lower parts of these corals. The mass occupies the axis, and the rounded top is artificial. *Smilotrochus insignis,* nobis, is not a *Ceratotrochus,* and one of the reasons is that it has no columella.

Smilotrochus granulatus, nob. (*op. cit.* p. 36, pl. xiv. fig. 17). This is said by Mr. Tomes to be an immature *Trochocyathus Wiltshirei,* nobis. I should have been glad to have seen a specimen of the interesting *T. Wiltshirei,* and still more to have seen the proofs that a well-characterized *Smilotrochus* without columella and pali could become a form with those essential characters in the growth of one-tenth of an inch, and also increase from three to four cycles in the same space. The height of the type *T. Wiltshirei,* nob., is three-tenths of a inch, and that of the *Smilotrochus* is two-tenths of an inch. The cyclical arrangement and the nature of the costæ and of the calice distinguish the two forms perfectly. There is no evidence that one form could turn into another, and the species *Smilotrochus granulatus,* nobis, is not the same as *T. Wiltshirei,* nobis, for it has neither columella nor pali.

Podoseris mammiliformis, nobis, and *P. elongata,* nobis (Pal. Soc. *loc. cit.* p. 25, pl. ix. figs. 2–17). These species are stated to be species of *Rhizangia,* Ed. and H. To disprove this it would suffice to draw attention to the above-mentioned figures of the types and to the figures given of *Rhizangia* by Reuss (Denks. d. Wien. Akad. der

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[1] Not spongy as Mr. Tomes states.

Wiss. t. vii. p. 120, pl. 7, fig. 7, 8, and fig. 9–11; also M. Ed. and Haime, Ann. des Sci. Nat. 3rd ser. t. x. pl. 7, fig. 7 and 8); but it is as well to call attention to the fact that perfect specimens of *Podoseris* have convex and more or less hemispherical upper surfaces, and that their bases are perforated, whilst there are synapticulæ between the septa. The form is not a social one, and never springs from stolons like *Rhizangia*, which has a wall, a flat upper surface with a shallow calice, and is seated upon a stoloniferous base which may extend beyond and give origin to others.

The figures given by Mr. Tomes (7 and 8) show that there are no stolons present. A stolon is a structure on which the bases of corallites grow, and it is not a growth from the edge of the base of a corallite. In the very numerous specimens of *Podoseris* from the Red Chalk which the Rev. Mr. Wiltshire placed at my disposal there were no traces of stolons. No union by stoloniferous growth existed in the specimens which were exhibited by Mr. Tomes at the Geol. Soc., and although he states that "three corallites are united by the stolon" (p. 552), it does not appear in the illustration (Fig. 7). I especially drew attention to the want of stolons and such union in the remarks I made on Mr. Tomes's paper at the Geological Society, and my remark was published in the Abstract of Proceedings. Nevertheless, Mr. Tomes persists in stating what he cannot substantiate.

I draw attention to Mr. Tomes's Fig. 10, which professes to represent synapticulæ. On Plate XIV. is printed "R. F. Tomes, del.," so that this is not a mistake of the artist. The figure proves that its author has views regarding the nature of synapticulæ which are not those of any other zoophytologist. Synapticulæ pass from one septum to another. In Fig. 9, synapticulæ are called dissepiments. Figure 11 of the Plate is acknowledged to be wrong, and should not have been printed, for it leads to a mistaken view of the structures it purports to represent. *Syzygophyllum*, Reuss, is not in the least like a *Podoseris*, and is synonymous with *Antillia*, nobis, a subgenus of *Circophyllia*; it has no stolons. *Podoseris* is a well-defined natural genus and is one of the Fungidæ, and *Rhizangia* is one of the Aporosa.

Turbinoseris, nobis ("Revision of the Genera," p. 148). This genus is stated by Mr. Tomes to be synonymous with *Leptophyllia*, Reuss. They are distinct for morphological reasons. Pratz in his article (Palæontographica, 1882, p. 90) has shown that the septa of *Leptophyllia* are numerous, thin, often uniting and composed of vertical trabeculæ with vertical rows of perforations between them. It may be remarked that this lattice-work condition is not the result of fossilization or weathering, but that it is normal, and necessitates the species being placed with *Cyclolites* and other forms in a special family of the Fungidæ.

Turbinoseris has many species, and I have described them from the West Indies and from Sind, besides from the British Cretaceous. In all, the septa are solid, and that is sufficient to separate the two genera. *Turbinoseris* remains a member of the Lophoserine group of the Fungidæ. *Turbinoseris de Fromenteli*, nobis, therefore retains its title, and Mr. Tomes cannot term it *Leptophyllia Anglica*, Tomes.

Mr. Tomes remarks (p. 545), "Some other compound corals have been collected at Haldon which, from their unsatisfactory condition, cannot be determined, though I believe them to be new. As the Haldon corals *are only casts*, they cannot be trusted when internal structure is important. The genus *Haldonia* is in my opinion a very doubtful one. Specimens in my own collection from Haldon differ in the important respect of sometimes having a styliform columella, and sometimes only a ring of pali, as in Prof. Duncan's figures." *Haldonia* was described and figured by me (Quart. Journ. Geol. Soc. 1879, vol. xxxv. p. 91), and like all the other forms I studied was *not in the form of cast*. *Haldonia Vicaryi*, nobis, was described from perfect specimens, and they had no columella. Corals of the same species, so far as my experience helps me, do not sometimes have a columella, and sometimes not and only pali. Probably the specimen seen by Mr. Tomes with a columella was the well-known *Actinacis* of Haldon.

I draw attention to the figures on the Plate (Geol. Mag. 1885, Pl. XIV. Figs. 14–15), and protest against species being determined from such fragments.

Finally, on looking at Fig. 13, which is said to represent a *Pleurosmilia*, it will be noticed that the columella does not terminate by uniting with one of the principal septa which is more developed than the others. The form does not belong to that genus, but to *Placosmilia*, Ed. and H.

SUMMARY, ETC.

Smilotrochus insignis, nobis, non *Ceratotrochus insignis*.
——— *granulatus*, nobis, non *Trochocyathus Wiltshirei*.
Micrabacia Fittoni, nobis, non *Cyclocyathus Fittoni*, Ed. and H.
Podoseris mammiliformis, nobis, non *Rhizangia mammiliformis*.
——— *elongata*, nobis, non *Rhizangia elongata*.
Turbinoseris de Fromenteli, nobis, non *Leptophyllia Anglica*, Tomes.
Pleurosmilia neocomiensis, E. de From. fide Tomes, is *Placosmilia*.
Haldonia, nobis, has no columella.
Syzygophyllum, Reuss, non *Rhizangia*, Ed. and H.

III.—ON THE SO-CALLED "GAULT" OF WEST DEREHAM, IN NORFOLK.

By Clement Reid, F.G.S., and George Sharman.

(Published by permission of the Director-General of the Geological Survey.)

SINCE the publication of William Smith's Map of Norfolk in 1819, the sections around West Dereham and Shouldham have been accepted as proving the occurrence of true Gault[1] in this part of West Norfolk. Messrs. Rose,[2] Fitton,[3] and later writers, all accept this determination. Mr. Teall,[1] writing in 1873, points out the close relation of the fossils from the "Coprolite Bed" of West Dereham to those of the "Ammonites mammillaris zone" of Folkestone, and correlates the overlying blue marly clay with the Gault, from the occurrence in it of *Ammonites interruptus.*[2]

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[1] The Kimmeridge Clay is also locally known as "Gault."
[2] Phil. Mag., series 3, vol. vii. pp. 171—182.
[3] Trans. Geol. Soc., series 2, vol. iv. p. 312.

However, during the Geological Survey of this neighbourhood, great difficulty was found in separating the so-called "Gault" from the Chalk Marl, and after a minute examination of the whole district, the only boundary-lines which could be traced were, a distinct line of erosion below the "Coprolite Bed," and a lithological line where the hard Chalk rests on the Chalk Marl. Though close search was made for the more or less phosphatic bed which in many other parts of England marks the base of the Chalk, no trace of it could be found, and the conclusion could not be avoided, that the so-called Gault was both lithologically and stratigraphically merely part of the Chalk Marl.

The new Coprolite Works lately opened at West Dereham show the best sections of the Phosphate Bed, and of the Marl immediately overlying it; but the Marl there is very thin, being partly cut out by Boulder-clay. In October, 1883, the section seen in the well was:

		Ft.	in.
CHALK MARL	5. Boulder-clay, very chalky	7	0
	4. Blue Marl, drying bluish white	4	0
	3. Coprolite Bed	0	9
NEOCOMIAN ...	2. Hard loamy nodular Greensand	2	0
	1. Running Sand		

The other parts of the works are on lower ground, and show less Boulder-clay; though the Marl is about the same thickness, except in one place, where Boulder-clay cuts through it into the Greensand, and in other parts where the Coprolite Bed approaches the surface.

Taking the beds in order, No. 1 is undoubtedly Neocomian, though here it has yielded no fossils. No. 2 is probably also Neocomian, which has been slightly disturbed, reconstructed during the deposition of the overlying beds, and subsequently hardened by infiltration.

No. 3 is the bed for which the deposit is worked. It consists of a mass of phosphatic nodules in a greenish loamy or sandy matrix, partly derived from the underlying Neocomian Beds. Mixed with and occasionally imbedded in the nodules are numerous fossils. These fossils seem to be mainly derivative, for though most of them, as Mr. Teall has pointed out, belong to the zone of *Ammonites mammillaris*, there is apparently also an occasional admixture of older and newer forms, including some species, such as *Dentalium ellipticum*, probably belonging to the Gault.

The "Coprolite" occurs in this bed in two forms. The more abundant is a poor sandy phosphate in irregular nodules, which may have been partly formed in the bed itself. These seldom contain fossils. The associated mollusca are generally either loose casts, or are imbedded in a sandy matrix which has not been phosphatized, though the shells themselves are usually coated internally with a smooth-grained black phosphate. Unfortunately, in so coarse a bed there is not much chance of finding the contemporaneous fauna preserved, and as nearly all the collecting has been done after the material has been roughly washed by machinery, any contemporaneous shells have probably been entirely destroyed. Collecting small fossils before the bed is washed is also very difficult, for it is impossible to see any, and the phosphate bed is not left to the action of the rain, but is immediately carted away.

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[1] The Potton and Wicken Phosphatic Deposits, 8vo. pp. 20, 21.

[2] See also Keeping's Neocomian Deposits of Upware, etc., 8vo. pp. 11, 54.

Leaving, therefore, the Phosphate Bed, which, though stratigraphically merely the basement-bed of the overlying Marl, cannot yet be proved to be so by evidence of the fossils, the undoubtedly contemporaneous shells of the underlying 3 or 4 feet of Marl (No. 4 of the section) were carefully collected and examined. The result showed, that while at first sight there was abundance of evidence for the correlation of the Marl with the Gault, yet closer examination proved the Gault fossils to be derived, and the contemporaneous fauna to belong to the Chalk Marl.

The following is a complete list of the fossils obtained in the Marl at West Dereham Coprolite Works—nearly all of them were found within two feet of the Coprolite Bed:—

Pentacrinus, sp.
Pseudodiadema, spine.

Serpula, sp.

Terebratula biplicata, Sow.
Rhynchonella, sp.

Anomia, sp.
Exogyra haliotoidea, Sow.
Ostrea acutirostris, Nilss.
——— *vesicularis*, Lam.
Plicatula, sp.
Pecten orbicularis, Sow.
——— *quinquecostatus*, Sow.
Inoceramus, sp.
Lima, sp.

Nucula pectinata, Sow. (cast).
Pholadidæa ? in wood.

Dentalium ellipticum, Sow. (casts).
Ammonites interruptus, Brüg. (casts).

Belemnites attenuatus, Sow.
——— *minimus* ? List.
——— *ultimus*, D'Orb.
Hamites, sp. (cast).

Beryx, sp. (in light-coloured phosphate).
Cymoliohthys ? (*Saurocephalus*) *striatus*, Ag.
Odontaspis gracilis, P. & C.
Pycnodus, sp.

Of these the most conspicuous and easily found, except the *Belemnites*, is *Ammonites interruptus*, which is a characteristic Gault form. But this species, and also *Hamites*, *Dentalium ellipticum*, *Nucula pectinata*, *Pholadidœa*, and the fish are all phosphatized, and usually rolled. They are probably derived from the Gault. The rest are white and unphosphatized, and are all known from the Lower Chalk of other districts. Two, *Ostrea vesicularis* and *O. acutirostris*, have not been discovered below the Chalk.

Around West Dereham numerous trial-holes have lately been made to prove the Coprolite Bed, and most of these were still open while the Survey was in progress. Unfortunately, none of them show more than from two to four feet of the overlying Marl, nor do the old works appear to have exposed any deeper section. Everywhere *Belemnites attenuatus*, *B. ultimus*, and *B. minimus* ?, are abundant, and associated with them is often found the phosphatized *Ammonites interruptus*.

To obtain the fossils of the Marl unmixed with derivative forms, an old pit at Muzzle, about a mile W.N.W. of West Dereham, was searched. This locality has been mentioned by several writers as showing a typical exposure of Gault, and it is interesting to find that not a single characteristic Gault form occurred, but that there were several species which have not been recorded from below the Lower Chalk.

The section, which is very good, though the pit is now seldom worked, shows a nearly vertical face of obscurely bedded blue marl with small black phosphatic concretions. Belemnites are scattered promiscuously throughout. Several years ago a trial was made in this pit for the 'Coprolite Bed,' and it was reached three feet below the floor; but only a few nodules were found, and the bed was too thin to work. This section, therefore, is an upward continuation of the one at the new Coprolite Works, but the lower three feet of Marl being unworked, there is no complication from derived fossils. The following species were obtained, but no doubt longer search would soon add to the number:—

Pentacrinus, 2 sp.
Pseudodiadema, sp.

Serpula, sp.

Kingena lima, Defr.
Terebratulina gracilis, Schlot.
———————— sp.

Ostrea vesicularis, Lam.

Plicatula, sp.
Inoceramus, sp.

Ammonites (fragment).
Belmnites attenuatus, Sow.
———— *minimus*? List.
————— *ultimus*, D'Orb.

Fish vertebra.

All of these occur in the Chalk or Chalk Marl, and the same three *Belemnites* are found in the Red Chalk of Hunstanton, which has lately been shown probably to belong to the Lower Chalk.[1] Thus it seems that the so-called Gault of West Dereham all really belongs to the Chalk Marl, and in this part of Norfolk the Gault is only represented by its derivative fossils in the basement bed of the Chalk. This greatly simplifies the geology, as, instead of two unconformities close together, there is only one, the Chalk Marl having cut through the Gault, and having cut also a considerable depth into the underlying Neocomian.

There is a long dip-slope near West Dereham, which keeps the Coprolite Bed conveniently near the surface over more than a square mile. But the uncertainty of the dip renders it very difficult to estimate the thickness of the Chalk Marl, which may be only 20 feet or over 50 feet. Unfortunately, the bed can only be traced for a short distance. East of the Fenland it first rises above the marsh-level at Wretton, and extends about three miles to the north-west, to Crimplesham, with an outlier capping the hill at Muzzle.

At Crimplesham it is lost beneath the Boulder-clay for about three miles, but reappears south of Shouldham as a bluish marly Clay full of *Belemnites attenuatus*, *B. minimus*? and *Plicatula*. In lithological character and fossils it is exactly like the Marl of West Dereham, but the Coprolite Bed, though searched for, could not be found. Only one section, in a deep ditch, could be examined; but the width of the outcrop shows that the Marl cannot be much less than 20 feet in thickness, though apparently thinner than at West Dereham.

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[1] See Whitaker, Presidential Address to the Norwich Geol. Soc. 1882, Proc. Nor. Geol. Soc. vol. i. pp. 207–236.

IV.—THE LOWER LIAS OF LEICESTERSHIRE.

By H. E. QUILTER.

THE Lower Lias in Leicestershire commences with clays and limestones (Strensham Series), succeeded by clays and shales. In its palæontological characters, as well as in its petrological features, it agrees in the main with the Lias of contiguous districts.

The following life-zones are apparently represented, viz. zones of *Ammonites planorbis*, *angulatus*, *Bucklandi*, *semicostatus*, *oxynotus*, *armatus*, *Jamesoni* and *capricornus*.

The junction of the Rhætic beds and the Lower Lias may be seen at Wigston, near Leicester; this section has been fully described.[1] In the clay-pits at this place may be seen, resting upon Rhætic shales, about 9 feet of limestones and shales, containing a Liassic fauna.

A boring for Coal in 1883 at Crown Hill, near Leicester, after passing through Lower Lias limestones and shales, penetrated 26 ft. of Rhætic shales before reaching the Keuper.

Nowhere in the county, so far as I am at present aware, is the true relationship between the Lower and Middle Lias clays shown. The palæontological evidence of other exposures, however, favours the view adopted by the Geological Survey,[2] that the uppermost beds of the Lower Lias are those of the zone of *Am. capricornus*.[3]

Zone of *A. planorbis*.

The limestones and clays of this zone (the Fish, Insect, and Reptilian beds) are well exposed at Barrow-on-Soar, where they are shown to a thickness of 25 feet. The 9 feet of limestone and shales resting upon Rhætics at Wigston are the lowest portion of this zone.

(?) Zone of *A. angulatus*.

A bed of pyritous shale, nearly 18 feet thick, containing *Æg. catenatum*, overlying the beds of the Planorbis zone at Barrow-on-Soar, has been referred to as the representative of the zone of *A. angulatus*. The railway cutting on the Uppingham Road, near Leicester, exposed about 12 feet of blue pyritous shale, also containing *Æg. catenatum*.

Three or four feet of blue clays exposed in brickyards at Bottesford are supposed to belong to this zone. With this exception, there does not appear to be any exposure of the beds of this zone. The position of the thick pyritous clays will be referred to in general conclusions.

[1] GEOL. MAG. Sept. 1884, p. 415.

[2] Mem. Geol. Survey. Geol. of Rutland, etc. J. W. Judd.

[3] This Ammonite was formerly considered to mark the *Middle* Lias (but see p. 86).

Zone of *A. Bucklandi.*

The beds of limestone and clay belonging to this zone are well exposed in the district. The chief sections being at Crown Hill. near Leicester, where nearly 50 feet of limestone and clay are exposed, and at Kilby Bridge, where about 36 feet of the same were shown. Exposures of a higher series of beds in this zone are given in a brickyard by the canal side, near Great Glenn Railway Station, showing 14 feet of dark-blue pyritous shales, with limestone nodules, full of fossils. At the time of writing, brickyards at Fleckney show from three to four feet of these clays.

During the excavations for the Great Northern Railway from Leicester to Tilton, about 12 feet of blue pyritous clays were cut through at the entrance of Ingarsby Tunnel.

Zone of *A. semicostatus.*

This zone is not now so well exposed in the Vale of Belvoir as during the Geol. Survey in 1874. When fully exposed, it was seen to be a thick hard band of ferruginous limestone. It is fossiliferous, but the present scarcity of exposures prevents any investigation.

Prof. J. W. Judd, F.R.S., in his Memoir gives a list of fossils.

Zone of *A. oxynotus.*

The shales of this zone could formerly be examined remarkably well at a tunnel between Grimston and Old Dalby, on the Notts and Melton Branch Railway. The section is now unfortunately covered up, but the heaps of *débris* on the top of the tunnel show thinly laminated blue shales, with ferruginous and limestone nodules, and shelly bands of limestone. The shales when weathered are, in places, richly fossiliferous, and judging from their present position on the shale heaps, there would appear to be a regular disposition of the fossils in bands or levels in the section, species of fossils being confined to one place or heap in the *débris.*

These shales with characteristic fossils are also exposed in a brickyard between Houghton and Billesdon. The section there shows about six feet of blue laminated shales, with pyritous bands, and scattered ironstone nodules, which are more numerous towards the top of the section.

Zone of *A. armatus.*

The beds of this zone are well exposed at Loseby brickyard and in the railway cuttings at Loseby Station.

The sections at both localities show about 26 feet of blue laminated shales, with numerous ironstone nodules, and a sandy indurated rock-bed about one foot thick near the base.

A similar section showing about 20 feet of shales with limestone and ironstone nodules, which appear to be in beds of this zone, is exposed at Loseby brickyard.

Zone of *A. Jamesoni.*

So far as I am aware, there are no good exposures of the beds of dark blue clays with septaria of this zone. They appear to be exposed in the brickyard at Woolsthorpe. During drainage operations near Woolsthorpe (August, 1884), about three feet of these clays were shown. Prof. Judd mentions exposures in the banks of the River Eye.

Zone of *A. capricornus.*

The beds of this zone were well exposed in a field dug for ballast during the recent alterations in the railway near Market Harborough. Six feet of blue shales with abundance of hard limestone nodules containing fossils were shown. Above these were seven feet of thickly laminated blue pyritous shales, containing ironstone nodules, and quite unfossiliferous. A small section of these latter beds is to be seen in a brickyard at the foot of the hill near Meville Holt.

TABLE OF FOSSILS.

SHOWING THEIR RANGE THROUGH THE ZONES.

SPECIES.	ZONE OF							
	A. planorbis.	*A. angulatus.*	*A. Bucklandi.*	*A. semicostatus.*	*A. oxynotus.*	*A. armatus.*	*A. Jamesoni.*	*A. capricornus.*
Plesiosaurus megacephalus	x	...	...	...	...	...	...	...
Ichthyosaurus communis, Conyb.	x	...	...	...	...	...	...	...
——— *tenuirostris*, Conyb.	x	...	...	...	...	...	...	...
——— *intermedius*, Conyb.	x	...	...	...	...	...	...	...
——— *platyodon*, Conyb	x	..	...	...	...	...	...	...
(Saurian remains)	x	...	x	...	...	x	...	..
Dapedius orbis	x	...	...	...	...	...	...	...
Belonostomus acutus, Agass.	x	...	...	...	...	...	...	...
Pholidophorus Hastingsiæ	x	...	...	...	...	...	..	...
——— *Stricklandi*	x	...	...	...	...	...	...	...
——— *Egertoni*	x	...	...	...	...	...	...	...
Leptolepis sprattiformis (?)	x	...	...	...	...	...	...	...
(Fish remains)	x	...	...	...	...	...	...	..
Ægoceras planorbis, Sow	x	...	...	...	...	...	...	...
——— *Johnstoni*, Sow.	x	...	...	...	...	...	...	...
——— *tortilis*, D'Orb	x	...	...	...	...	...	...	...
——— *catenatum*, Sow.	...	?	...	...	...	...	...	...
——— *angulatum*, Schloth	...	...	x	...	...	...	...	...
——— *Charmassei*, D'Orb	...	...	x	...	...	...	...	...
——— *polymorphum*, Quenst.	...	...	x	...	...	...	...	...
——— *Jamesoni*, Sow	...	...	...	...	x	...	x	...
——— *Taylori*, Sow.	...	...	...	...	x	...	...	...
——— *Valdani*, D'Orb.	...	..	...	...	x	...	...	...
——— *Henleyi*, Sow.	...	...	...	...	x	...	...	x
——— *curvicornum*, Schloth.	...	...	...	...	x	...	...	...
——— *armatum*, Sow	...	...	...	...	...	x	...	...
——— *striatum*, Rencke	...	...	...	...	...	x	...	...
——— *brevispinum*, Sow.	...	...	...	...	...	...	x	...
——— *capricornum*, Schloth.	...	...	...	...	...	...	...	x
——— *gagateum*, Y. & B.	...	...	...	...	...	...	...	x
Arietites Bucklandi, Sow	...	...	x	...	...	...	...	...
——— *Sauzeanus*, D'Orb	...	...	x	...	...	...	...	...
——— *obesulus*, Blake	...	...	x	...	...	...	...	...
——— *Conybeari*, Sow.	...	...	x	...	...	...	...	...
——— *scipionianus*, D'Orb	...	...	x	...	...	...	...	...
——— *semicostatus*, Y. & B.	...	...	x	x	...	...	...	...
——— *ophioides*, D'Orb.	...	...	...	...	...	x	...	...

SPECIES.	ZONE OF							
	A. planorbis.	*A. angulatus.*	*A. Bucklandi.*	*A. semicostatus.*	*A. oxynotus*	*A. armatus.*	*A. Jamesoni.*	*A. capricornus.*
Amaltheus oxynotus, Quen.	...	...	...	...	x	...	...	...
Phylloceras Loscombi, Sow.	...	...	...	...	x	x	...	...
Lytoceras fimbriatum, Sow.	...	...	...	...	...	...	...	x
(***Ammonites latæcosta***, Sow.)	...	...	...	...	...	...	x	...
(——— ***Normanianus***, Sow.)	...	...	...	...	...	...	x	...
Nautilus striatus, Sow	x	...	x	...	...	...	...	...
——— ***truncatus***, Sow	...	...	...	...	...	x	...	...
Belemnites infundibulum, Ph.	...	...	x	...	...	...	...	...
——— ***acutus***, Mill	...	...	x	x	?	x	...	...
——— ***elegans***, Simps.	...	...	...	...	x	...	...	...
——— ***clavatus***, Blainv.	...	...	...	...	...	...	...	x
Dentalium, sp.	...	...	x	...	...	...	...	...
Cryptænia consobrina, Tate.	...	...	...	...	x	...	...	...
——— ***expansa***, Sow.	...	...	...	x	x	...	...	...
Pleurotomaria anglica, Sow.	x	...	x	...	x	...	...	...
——— ***precatoria***, Desl.	...	...	...	x	...	...	...	...
——— ***princeps***, K. & D.	...	...	...	x	...	...	...	...
Trochus Thetis (?), Münst.	...	...	...	...	x	...	...	...
——— ***imbricatus***, Sow.	...	...	...	x	...	...	...	...
——— sp.	...	...	...	x	...	...	...	...
Turbo Dunkeri, Münst.	...	...	x	...	...	...	...	...
——— sp.	...	...	...	x	...	...	...	...
Eucyclus Gaudryanus, D'Orb.	...	...	...	...	x	...	...	...
——— ,, var. (?)	...	...	...	...	x	...	...	...
——— ***conspersus***, Tate	...	...	...	...	x	...	...	...
——— ***elegans***, Münst.	...	...	x	...	...	x	...	...
Turritella, sp.	...	...	...	...	x	...	...	...
Cerithium liassicum, Moore	...	...	...	...	x	...	...	...
——— ***varicosum***, Moore	...	...	...	...	x	...	...	...
——— ***asperulum***, Moore	...	...	...	...	x	...	...	...
——— ***Ibex***, Tate	...	...	...	...	x	...	...	...
——— ***ligaturalis***, Tate	...	...	...	x	...	...	...	...
——— ***subfistulosa***, Tate	...	...	...	x	...	...	...	...
Chemnitzia Blainvillei, Münst.	...	...	...	...	x	...	...	...
——— ***semitecta*** (?), Tate	...	...	...	...	x	...	...	...
——— ***citharella***, Tate	...	...	...	...	x	...	...	...
——— ***carusensis*** (?), D'Orb.	...	...	...	...	x	...	...	...
——— ***Berthaudi***, Dunn	...	...	...	...	x	...	...	...
Acteonina, sp.	...	...	...	...	x	...	...	...
Ostrea Liassica, Strick.	x	?	x	...	x	?	...	x
——— ***Goldfussi***, Bronn.	...	...	...	...	...	x	...	...
Gryphea arcuata, Lam.	x	?	x	x	x	x	...	...
——— ***cymbium***, Lam.	...	...	...	...	...	...	x	...
——— ***obliquata***, Sow.	...	...	...	...	...	...	x	...
——— ***Macullochi***, Sow.	...	...	...	...	x	...	...	...
Pecten lunularis, Römer	x	...	x	...	...	...	...	...
——— ***textorus***, Schloth.	...	...	...	x	...	...	...	...
——— ***equivalvis***, Sow.	...	...	...	x	x	...	...	...
——— ***Liasianus***, Nyst.	...	...	...	x	...	...	...	...
Lima succincta, Schloth.	x	...	x	...	...	...	...	...
——— ***Hermani***, Voltz.	x	...	...	...	...	x	x	...
——— ***gigantea***, Sow.	x	?	x	x	?	x	...	...
——— ***pectenoides***, Sow.	x	...	x	x	x	x	...	...
——— ***punctata***, Sow.	...	...	...	x	...	...	...	...
——— ***acuticosta***, Schloth.	...	...	...	...	...	...	x	...
Limea, sp.	...	...	x	...	...	...	...	...

SPECIES.	ZONE OF							
	A. planorbis.	*A. angulatus.*	*A. Bucklandi.*	*A. semicostatus.*	*A. oxynotus.*	*A. armatus.*	*A. Jamesoni.*	*A. capricornus.*
Plicatula spinosa, Sow.	...	...	x	...	x	x	x	...
——— *lævigata*, D'Orb. (?)	...	...	...	...	...	...	x	...
Avicula* (*Monotis*) *cygnipes, Y. & B.	..	...	...	...	...	x	...	...
Perna infraliassica, Quen.	...	...	x	...	...	...	...	...
Inoceramus ventricosus, Sow.	...	...	...	...	x	...	...	...
Pinna folium, Y. & B.	...	...	...	...	x	x	...	.
Modiola minima, Sow.	x	...	...	...	...	...	...	...
——— *lævis*, Sow.	...	...	x	...	...	...	...	...
——— *Hillana*, Sow.	...	..	x	x	...	...	...	...
——— *Morrisii*, Oppel.	...	...	...	x	...	...	...	...
——— *scalprum*, Sow.	...	...	x	...	x	x	?	x
Nucula variabilis, Quen.	...	...	...	...	...	...	...	x
Leda galathea, D'Orb.	...	...	..	...	x	...	...	x
——— *minor*, Simps.	...	...	...	...	x	...	...	...
——— *complanata*, Goldf.	...	...	...	...	x	...	...	...
Cardinia Listeri, Sow.	...	...	x	...	x	...	...	..
——— *gigantea*, Quen.	...	...	...	x	...	...	...	...
——— *copides*, Ryck.	...	...	...	x	...	...	...	...
——— *hybrida*, Sow.	...	...	...	x	...	...	...	...
——— *ovalis*, Stutch.	...	...	...	x	...	...	...	...
Cypricardia cucculata, Mün.	...	...	...	...	...	x	...	...
Hippopodium ponderosum, Sow.	...	...	x	...	x	x	...	...
Protocardium Phillipianum, Dunk.	...	...	...	...	x	...	...	...
Unicardium cardioides, Phill.	...	...	x	x	x	x	x	...
Pholadomya glabra, Agass.	...	...	x	...	...	...	...	...
——— *ventricosa*, Agass.	...	...	...	...	x	...	...	...
——— *ambigua*, Sow.	...	...	...	...	...	x	...	...
——— *decurata*, Hartm.	...	...	...	...	...	...	x	...
Goniomya hybrida, Münst.	...	...	...	...	...	...	...	x
Pleuromya striatula	...	...	x	...	x	...	...	...
——— *unionides*, Röm.	...	...	...	x	...	...	...	...
——— sp.	...	...	...	...	x	...	...	...
Arcomya vetusta, Phil.	...	...	...	...	x	...	...	...
Spiriferina Walcotti, Sow.	...	...	...	...	x	...	x	...
——— *verrucosa*, V. Buch.	...	...	...	...	x	...	...	...
Terebratula punctata (?), Sow.	...	...	...	x	...	...	...	...
Waldheimia numismalis, Lam.	...	...	...	...	x	...	...	...
——— *perforata*, Piette	...	...	x	...	...	x	...	...
Rhynchonella plicatissima, Quen.	...	...	x	...	x	x	...	...
——— *tetrahedra*, Sow.	...	...	...	...	x	...	...	...
——— *variabilis*, Schloth.	...	...	...	x	...	...	...	...
Buprestis (Elytron of), Brodie	x	...	...	...	...	...	...	...
Libellula (Wing of), Brodie	x	...	...	...	...	...	...	...
Eryon Barroviensis, M'Coy	x	...	...	...	...	...	...	...
——— sp.	...	...	x	...	...	...	...	...
(Crustacean remains)	...	...	...	...	x	...	...	...
Serpula capitata, Phill.	...	...	...	x	...	..	...	...
——— (species of)	x	...	x	...	x	x	x	...
Cidaris Edwardsii, Wrt.	x	...	x	...	?	...	...	...
Hemipedina Tomesii, Wrt.	x	...	...	...	...	...	...	...
Pentacrinus psilonoti, Quen.	x	...	x	...	...	...	...	...
——— *punctiferus*, Quen.	...	...	...	...	...	...	x	...
——— *robustus*, Wrt.	...	...	...	...	...	...	...	x
Montlivaltia Guettardi, Blain.	...	...	x	...	...	...	...	...
——— *mucronata*, Dunc.	...	...	...	...	x	...	...	...
Lepidophyllia Hebridensis, Dunc.	...	...	...	x	...	...	...	...

Mr. E. Wilson, F.G.S., who has rendered me great assistance in the above list, also informs me that he detected *Foraminifera* in several of the Lower Lias clays of the district; in particular from the *A. oxynotus* shales at the Tunnel near to Old Dalby Station, from whence he has obtained no less than thirty forms, the following genera being represented:—

Nonionina.
Frondicularia.
Involutina.
Lingulina.
Pulvinulina.
Planularia.
Textularia.
Dentalina.
Cristellaria.
Orbulina.
Nodosaria.
Marginulina.
Cornuspira.
Miliola.

General Conclusions.

Considering the few and comparatively unimportant exposures of these rocks in Leicestershire, and the consequent difficulty of obtaining a complete series of fossils, a classification of the beds into life-zones would seem hardly feasible. Sufficient has been done, however, to make the case good. Nevertheless, it would be premature at present to make any deductions with regard to the passage of important species from one zone to another.

The apparent non-development of the zone of *A. angulatus*, and the intercalation of the zone of *A. semicostatus*, with the zones of *A. Bucklandi* and *A. oxynotus*, may perhaps be made the subject of remark. That the beds of the zone of *A. angulatus* are present is highly probable.

Mr. J. D. Paul, F.G.S., informs me that 186 feet of Lower Lias limestones and clay were passed through in the boring at Crown Hill, near Leicester. Deducting from this, say 40 feet, for the maximum thickness of the beds belonging to the zone of *A. planorbis*, and 60 feet for the thickness of the lower beds of the zone of *A. Bucklandi*, which are, as already mentioned, exposed here, about 86 feet of the beds passed through in the boring remain to be accounted for.

As bearing on this point, I would here note the similarity of the sections at Kilby Bridge and Crown Hill, and the occurrence of *Æg. angulatus* in the lower beds of these exposures, showing that these beds are not far from the junction of the zones of *A. angulatus* and *A. Bucklandi*.

The 86 feet, or thereabouts, remaining to be accounted for, may reasonably be assigned to the zone of *A. angulatus*. The thick bed of clay exposed at Barrow-on-Soar, and in the railway cutting on the Uppingham Road, near Leicester, has also been thought to represent the zone of *A. angulatus*; but if my supposition be correct, this is not so.

The fauna of this bed is so scanty, containing only *Æg. catenatum*, *Lima gigantea*, and *Gryphea arcuata* (the two latter being dwarf forms), that we can learn nothing from it; but the occurrence of *Æg. catenatum* in this bed only is peculiar and interesting. *Æg. catenatum* appears to be an evolutionary form between *Æg. planorbis* or *Æg. Johnstoni* and *Æg. angulatum*.

From this, I assume this thick bed of clay to be a bed containing a transition fauna between the zones of *A. planorbis* and *A. angulatus*, not so well developed perhaps in other districts.

Under these circumstances, should the zone of *A. angulatus* be eventually exposed, and with more exposures, an assemblage of fossils be found in the clays containing *Æg. catenatum*, then those clays should be placed in the position of a subzone—the subzone of *A. catenatum*. For the present, however, it might be termed the "Catenatus bed," and separated on those grounds from the zones of *A. planorbis* below and *A. angulatus* above.

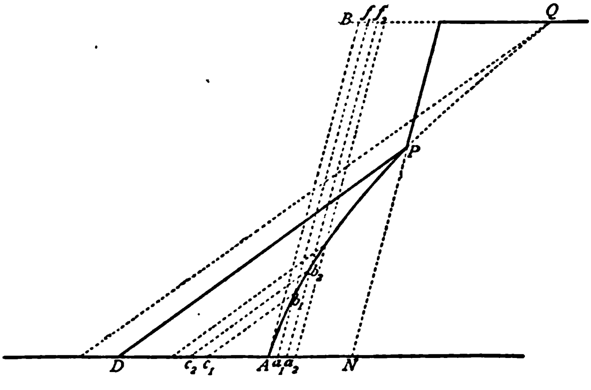
The occurrence of the interesting zone of *A. semicostatus* is an example of the fluctuations of the zones of the Lias formation in districts or areas, and how species perhaps only of secondary importance in one zone, under certain conditions of environment may be of capital importance in another.

I have to acknowledge the assistance of Prof. Blake, of Nottingham, who has kindly determined many of the fossils for me, and also that of Mr. E. F. Bates, of Leicester.

V.—NOTE ON THE FORM OF THE UNERODED SURFACE OF ROCK UNDERNEATH A TALUS.

By CHARLES DAVISON, M.A.;
Mathematical Master at King Edward's School, Birmingham.

IN the case of a vertical cliff, Mr. Fisher has shown that the uneroded surface of rock underneath a talus is in the form of a semi-parabola.[1] The object of this note is to show that the form is parabolic, even if the cliff be not initially vertical, assuming, with Mr. Fisher, (1) that the cliff-face is weathered uniformly at all points, and (2) that the disintegrated material is spread evenly over the surface of the talus, so as to maintain it always at the same slope. The proposition may be proved analytically, as in Mr. Fisher's paper, or geometrically as follows.



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[1] Rev. O. Fisher, "On the Disintegration of a Chalk Cliff," GEOL. MAG. (1866), Vol. III. pp. 354–356.

Let AB, the original face of the cliff, be inclined at an angle α to the horizon. In any given interval of time, suppose the layer ABf_1a_1 to be worn from the face of the cliff, and the material spread at the foot of the cliff as $a_1b_1c_1$, the surface b_1c_1 being plane and inclined to the horizon at an angle β. Let $AB=h$, $Aa_1=x_1$, $a_1b_1=y_1$.

Now, the parallelogram ABf_1a_1 is equal to a rectangle whose base is Aa_1 and height $h \sin \alpha$,

$$\therefore \text{ area } ABf_1a_1 = hx_1 . \sin \alpha,$$

and triangle $a_1b_1c_1 = \frac{1}{2} a_1c_1, a_1b_1 . \sin \alpha,$

$$= \tfrac{1}{2} a_1b_1 . \frac{\sin(\alpha-\beta)}{\sin \beta.} . a_1b_1 . \sin \alpha,$$

$$= \tfrac{1}{2} y_1^2 . \frac{\sin(\alpha-\beta) \sin \alpha.}{\sin \beta}$$

$$\therefore y_1^2 = \frac{2h \sin \beta}{\sin(\alpha-\beta)} . x_1.$$

During a second interval, equal to the first, let another layer of the same thickness be worn from the face of the cliff b_1f_1, and be deposited over the *débris* at the base, and inclined at the same angle β to the horizon, so as to raise the surface of the talus to b_2c_2. Let $a_2b_2=y_2$, and $Aa_2=x_2=2x_1$.

Now, area $f_1b_1b_2f_2=(h-y_1)\,x_1 . \sin \alpha$,
and area $c_1c_2b_2b_1=a_2b_2c_2-a_1b_1c_1-a_1b_1b_2a_2$,

$$= \tfrac{1}{2} y_2^2 . \frac{\sin(\alpha-\beta)\sin \alpha}{\sin \beta} - \tfrac{1}{2} y_1^2 . \frac{\sin(\alpha-\beta)\sin \alpha}{\sin \beta} - y_1x_1 \sin \alpha$$

$$\therefore \tfrac{1}{2} y_2^2 . \frac{\sin(\alpha-\beta)}{\sin \beta} = hx_1 + \tfrac{1}{2} y_1^2 . \frac{\sin(\alpha-\beta)}{\sin \beta} = 2\,hx_1.$$

$$\therefore y_2^2 = 4\,h . \frac{\sin \beta}{\sin(\alpha-\beta)} . x_1 = 2\,h . \frac{\sin \beta}{\sin(\alpha-\beta)} . x_2$$

Proceeding in this way, we see that after n layers have been worn away, we have

$$y_n^2 = 2\,h . \frac{\sin \beta}{\sin(\alpha-\beta)} . x_n.$$

Now, let each interval of time be supposed very small; then the layer disintegrated during each interval is very thin, and the form of the rock under the talus is a curve which has the property

$$PN^2 = 2\,h . \frac{\sin \beta}{\sin(\alpha-\beta)} . AN,$$

and is therefore part of a parabola whose axis is horizontal. The initial face of the cliff is a tangent to the curve at A, and the final surface of the talus, when it reaches the top of the cliff at Q, is a tangent to the curve at that point.

VI.—The Succession of the Later Tertiaries in Great Britain.

By Alfred Bell.

THOSE interested in the geology of the Upper Tertiaries must have noticed the divergence in the views entertained by different writers as to the succession of the various strata of which they are composed. Sundry causes may be assigned for this, such as the disposition in some quarters to regard the "lapse of time occupied in the accumulation of even our later Tertiary deposits" "as representing but a very brief chapter in geological history,"[1] or the massing of the several groups of strata in bulk, or putting aside as of little value the organic evidence they contain, which, even where this is appealed to, is too narrowly treated, as where one author—a specialist in his own branch—asks, "Could the more modern Tertiaries be classed by their Invertebrata?"

Not alone perhaps; but if all kinds of life are studied in correspondence with their surroundings, a natural sequence can be traced throughout their entire history.

Astronomical speculations as to the time when the Glacial epoch commenced or terminated, and the attempts thereby to determine the existence of Man upon the Earth, may be set aside as of little value at present; as Mr. Prestwich happily puts it, "the difficulties arising from astronomical theories are that they differ so much among themselves."[2]

A fair inference as to the time required may be drawn from the fossils. My lists give of the Eocene about 2500, and of the later Tertiaries above 3000 species, hardly any being in common.

In the following notes I have assumed that the constituents of the different deposits and their fossils are pretty well known to geologists, and I have therefore not attempted to locate *every* known bed, but to indicate the lines on which their classification is possible. A comparison betwixt that which I have here attempted and that adopted by Mr. J. Geikie will, I may say at once, indicate how widely divergent our respective views are. I take his as a standard of comparison as being the most extensive one brought forward hitherto.

I am probably biassed, but I cannot see any evidence in favour either of the numerous mutations of the surface, or alternate procession of the Northern and Southern Mammalia suggested in the "Great Ice Age," or that Britain was *ever otherwise than Continental* from the close of the Middle Red Crag age to that of the minor glaciation, about which time I consider it ceased to be so.

It may be laid down as a general rule that the fauna and flora march with the climate, *i.e.* cold with cold or the contrary, and that if by any possibility the temperature of any period can be ascertained, a corresponding organic life existed, circumstances being favourable thereto.

Of the preglacial deposits the admirable memoirs by Messrs. Clement Reid and E. T. Newton leave little to be said. I may, however, remark that the evidence of the Forest Bed being overlapped by the Bure Valley Beds is not so satisfactory as might be desired. I am more disposed to agree with Mr. H. B. Woodward in placing these marine beds on the same level as the Weybourne Sands, and as constituting the very upper part of the newer Pliocenes, since I find that, with the exception of *Tellina balthica*,[1] all the mollusca of these beds are found in the Butley Crags.

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[1] Dr. H. Woodward, On *Rhytina gigas.*

[2] Quart. Journ. Geol. Soc. vol. xxvii. p. 233.

The Quaternary, if not a very sound division of the Tertiary, is at least a very convenient one, and it is with the "Forest Bed" rather than the preceding Passage beds that it may be said to commence.

Mr. H. B. Woodward takes the view that the lapse of time between the Newer Crag and the Forest Bed may be inconsiderable; but there is not only the disappearance of the *Mastodon* to be accounted for, but the variation in the Mammalia as a whole; since, leaving out nine species in the Norwich Crags still existing, only four pass up to the Forest-bed, where at least 40 others occur for the first time. (Is there any confirmatory evidence of the existence of *Mastodon* in the later Thames gravel as recorded by Mr. Whitaker? Mem. Geol. Survey.)

The fluviatile mollusca, except for *Lithoglyphus*,[2] does not offer much for comment. The splitting up of the very minute Hydrobia by Sandberger into so many new species and a new genus will not commend itself to Conchologists generally.

Will Mr. Reid allow me to set one of his quotations right? I am represented as saying (Mem. Country around Cromer, p. 74) that Mr. Prestwich's *Unio margaritifera* in reality is *Unio littoralis*. If he will turn to the GEOL. MAG. Vol. IX. 1872, p. 214, he will find *I said nothing of the kind, but that it was an Anodon*, as he himself assigns it. The specimen referred to is in the Norwich Museum. Again, on what grounds does he transfer the *Limax agrestis* of my Forest Bed list to *L. modioliformis?* The Forest Bed Mollusca I collected myself. *Silpha dispar* may be also added to the Coleoptera.

Inasmuch as Mr. Newton has rehabilitated in the Forest Bed *Hyæna spelæa* after having once rejected it, I hope he will be able also to replace the other species he has excised from the Forest Bed list compiled by my brother and myself.

Between the temperate Forest Bed flora and the intensely Arctic one above it the measure of time must be a long one to allow for physical changes, as the Forest Bed must have been submerged at least six or eight fathoms, that being the average depth at which the Yoldias found *in situ* in the intervening beds inhabit our modern seas, the Yoldia or *Leda myalis* beds being here 15 feet thick.

One of the chief objections to the Myalis bed being synchronous with the Bure Valley Beds is the fact that several of the species, *Leda* included, are found in their living position. It may be also worth noting that the *Leda myalis* does not occur in the inland Bure Valley Beds or the Weybourne Crags, where *L. oblongoides* (*L. limatula*) is the representative species, and of the 18 Bure Valley marine species, eight do not occur in the Myalis Bed; and of the 15 species in the latter, nine are not found in the Bure Valley.

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[1] The presence of this shell seems to indicate that great hydrographical changes had taken place, probably the influx of a heavy current setting in from the north, bringing the Tellen in profusion. It sufficiently distinguishes the beds in which it occurs from the immediately preceding Upper Crag or the Chillesford Series.

[2] This is the recent species figured in Forbes and Hanley's British Mollusca as *Natica Kingi*, obtained in the rubbish of a fishing boat at Cullercoats.

I may call Mr. Reid's attention to a very valuable paper by Dr. Nathorst, on this Arctic plant-bed, in vol. iii. of the Journal of Botany, London, which Mr. Reid seems to have overlooked (*op. cit.* p. 83), in which the Doctor records the species he obtained, including a large number of Willows and Mosses now living only within the Arctic circle.

It is generally assumed that a great elevation of the land was taking place throughout the earlier part of the major glaciation, culminating in a rise to at least the 100-fathom line, raising the whole bed of the North Sea, except a narrow valley towards the Norway coast—the ice-sheet then generated not extending to the South of Britain. Of the land or sea life of this period there is no record in Britain, but it may be surmised that the Mammoth and *Rhinoceros tichorhinus*, the Wolverine and the Musk Sheep roamed the frozen solitudes in scanty numbers. That which would be most consonant with the climate is found in the masses transported bodily from some unknown deep-sea locality, imbedded in the higher Yorkshire Clays at Bridlington and elsewhere (*vide infra*), the few fragments mentioned by Mr. Reid from the Cromer Drift being doubtfully *in situ*.

Subsidence of the land is indicated by the erosion prior to the deposition of the wide-spread sheets of Middle Glacial sand and gravel extending from Shropshire to Belgium (if, as Mr. S. V. Wood suggested, the Sables de Campine are of this age). These sands are mainly, and I am inclined to think altogether, unfossiliferous. The very fragmentary condition of the large number of species (94) recorded by Mr. Wood from these sands, and the fact that except six or seven all are present in the Butley Crag, induce me to think, contrary to the opinion of the Messrs. Wood and Harmer, that, like the corresponding sands of Slains and Cruden, containing fragmentary Red Crag shells, they are purely derivative.[1] It is also difficult to see where such a fauna could have existed in continuity throughout the preceding stages, if the bed of the North Sea had been elevated to the extent supposed. These sands and gravels are apparently due to the floods let loose by the melting ice, excessive rainfall, and the sorting action of the sea as a greater area was brought under its influence while the land slowly subsided. The immense influx of freshwater would be unfavourable to the development of marine life which in the Anglo-Belgian Gulf had ceased to exist, the incoming northern fauna being unmodified by southern accretions till the future minor glaciation had passed away, and the communication re-opened between the Channel and the North Sea.

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[1] Traces of Red Crag Shells, *Pecten opercularis*, have also been found in the westerly extension of the Middle Glacial.

On the western side of Britain a different set of conditions obtains in the beds beneath the Till in Kilmaurs, Tangy-Glen, and elsewhere. Of the 22 species recorded, 17 are still British; but the remaining five are extra-British, new to the fauna, and of true northern types corresponding to those on the east coast of Bridlington and Fife, as will be discussed presently.

The climax of the Glacial epoch occurs with the Great Chalky Boulder-clay, the true Scottish Till, the drift and unfossiliferous Till of the Midlands and north-west from Lancashire to Shropshire. From the presence of occasional horns, bones, and teeth in the Scottish clays, the remission at times of the intense cold may be inferred, as in the Greenland summer. I have no knowledge of the Crofthead Peat, except from the kindness of Mr. Mahoney, and his and Mr. Geikie's papers in the GEOL. MAG. Vol. II. 1869; but, considering all the evidence, I am less inclined to regard it as an intercalated deposit in the Lower Till than as occupying a depression at its immediate close, the overlying drifts corresponding more to the higher English Purple Clays than to true Till. The fauna and flora, including *Bos primigenius*, are certainly not Arctic, as they should be if Greenlandic conditions prevailed.

The Purple Clays of Yorkshire and Lincolnshire mark the close of the first Glacial epoch in Britain. The researches of Mr. Lamplugh have definitely settled the question as to the fauna of the intercalated masses of sand and clay in the basement beds not being in position. Of the 120 molluscs on record from Bridlington,[1] I find on analysis that 39 are confined to these sands, and of the others, 22 are now extra-British, all of the species being still existing. The age when these molluscs lived would probably be about the time when the Arctic plant-bed was forming on the now Norfolk coast, the *Nucula Cobboldiæ* and *Tellina obliqua* linking it to the Newer Pliocene fauna, their habitat in the deep North Sea not far removed from shore—a few miles perhaps—similar to the Dogger and Antrim turbot banks, where northern forms still exist. Mr. Dawson records a similar deposit about eight miles off Cruden, from whence his dredge always brought up dead shells of northern types; of the seventeen species recorded, nearly all are found at Bridlington, and like deposits are not uncommon elsewhere. The Bridlington fauna is essentially a deep-sea one, and in *no case* could have originated or formed in any of the deposits of the Glacial epoch in Britain.

With the gradual cessation of Arctic conditions, depression began again, lasting until the waves of the Atlantic washed the shores of a coast-line extending in an irregular tract from the Severn to the Tees, accompanied by excessive thermal changes and the inbringing of a new series of life forms. Eliminating all the Bridlington species as of doubtful British origin, and all land and freshwater mollusca on either side from the list of species *before* and *after* the major glaciation treated of above, there remain of the Newer

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[1] Dr. Jeffreys in working up the list of species in Mr. Lamplugh's paper omitted any reference to Mr. S. V. Wood's, and many other notices on the fauna.

Pliocene (Butley horizon[1]) 130 species which do not pass the barrier, replaced by 160 others; forty to fifty again of these dying out on or before the succeeding minor glaciation. Mr. Crosskey points out "that the fossiliferous sands, etc., belong to several ages, the contents indicating several groups, having their own place in the gradual transition from a severely arctic to a more moderate temperature." This transition I am trying to illustrate. The oldest of the Interglacial marine deposits occur in the flanks of the Boulder-clay in Fife and Aberdeen, and, as might be expected, yield 22 extra-British species, of high Arctic types. After these may be grouped such beds as those of Bute and Arran, containing *Saxicava Norvegica*, and other boreal forms, without or with but a small proportion of more Southern forms, as at Paisley and Dalmeny later on.

Unless the raised beach at Portland Bill is of this age, there is no Marine deposit in South Britain that can be, so far as I am aware, correlated with this older group of Interglacial deposits; and the Lower Boulder-clays of Lancashire and the West containing *Cytherea Chione* are approximated by this shell to a slightly more recent period antecedent to the Middle Lancashire Sands.

The land fauna of this immediate Post-glacial age in Britain is very limited, the Mammoth, Woolly Rhinoceros, *Bos primigenius*, and the Reindeer, a new arrival, alone indicating the larger life in the north; but with the disappearance of the ice in lower lands, immigration began. Traces of such are found in the breccia of Kent's Hole, and the corresponding earth of the Brixham Windmill Caves, in the abundant relics of Cave Bear and the very rare Lion and Fox (White Fox) (1 jaw of each) and, as shown by his implements, MAN. The presence of these four Carnivora is indicative of the herbivora, none of which has as yet been found, and Mr. Pengelly would probably be quite right in his argument that Man arrived in Britain before the Cave Hyæna, if he had added "after the Glacial epoch." From all the facts of our present knowledge there seems no escape from making the earliest *Primæval Man* (revealed by his works in a Devonshire Cave, *for the first time* on record), an Old Devonian and a real *homo*, having nothing to do with the Eocene Ape Man of Thenay, or his Miocene brethren of the Cantal and the Tagus.[2]

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[1] I have used this horizon as a standard of comparison throughout, because of its accepted freedom from extraneous forms; and its richness in life offers sufficient ground for such reference.

[2] The evidence of Preglacial Man in England is confined to the Red Crag, and consists, 1st, of a shell with a supposed human face carved thereon (H. Stopes); 2nd, perforations in sharks' teeth (E. Charlesworth); 3rd, a human jaw deeply stained with iron from Foxhall (Dr. Collyer, Anthrop. Review, 1867, p. 221); 4th, a spear-head from a Coprolite heap, locality unknown (R. J. Mortimer, now in Brit. Mus.); and lastly, a specimen of apparently cut bone in possession of Prof. Prestwich (Nature, vol. xvii. p. 105). Of these the shell is probably like many other Walton shells fancifully decorticated; 2nd, the perforations are shown by Prof. Hughes to be due to animal action; 3rd, the jaw is repudiated by nearly all scientific men as of Preglacial age, although certainly old; 4th, Mr. Mortimer's implement has been fashioned since the fossilization of the bone. Mr. Prestwich's I have not seen. The absence of Palæolithic Mammals and Implements in either Scotland or Ireland is strong evidence in favour of an equal absence of dry land there.

The submergence of the north-west corresponds with the emergence or elevation of the east, and in the Glacial beds thus exposed the Thames river channel was opened, the oldest portion from East London to Ilford, Grays and Crayford, opening southwards (S. V. Wood), and at a later period, when the North Sea was resuming its old bed [inhuming the Mammalian fauna, brought up so frequently from its bottom by fishermen], the present channel in its entire length opening eastwards. These earlier gravels and brickearths yield a fauna indicating warmer conditions than now or at any time since the preceding glaciation. Grouped with these must be the rich Barnwell river gravels, containing more extra-British freshwater and land shells than all the other Post-Tertiary deposits put together, including *Helix fruticum, the only other* Post-Tertiary locality for which shell is Stutton on the Stour, a deposit of similar age, from whence the late Mr. S. V. Wood, sen., obtained the specimen (the only one) figured in Mon. Crag. Moll. I notice here this shell more particularly, because I shall have to call attention to certain erroneous references in respect to this species. The well-known deposit at Clacton Cliff belongs to this series: and here I must demur to Mr. Dalton collating the fauna at this place with that of Copford, especially without due revision. The Copford shells were named by one of the most competent men of his day, the late Mr. John Pickering, from Dr. Gray's edition of Turton's Manual, and the Clacton list by Mr. J. de C. Sowerby, in which two species are described as new, one being from the figure a variety of *Helix hispida*, and the other, judging from the description, a young *Planorbis glaber*. Mr. Sowerby used a different nomenclature from Mr. Pickering, and the incorporation of both lists into one without the elimination of the synonymic names unduly inflates the list of species (Memoirs of the Neighbourhood of Colchester, 1880).

The Worcestershire Avon gravels may be assigned to this series also, as, like the older Thames beds, the fauna of all kinds is marked not only by forms of southern types, but by an almost complete absence of northern and arctic species. The Musk Sheep would seem not to be in accordance with this view; but at present I should consider its occurrence at Crayford, Erith, and Freshford near Bath, to correlate these beds with the same age as the later Thames gravels near Maidenhead, when the declining was gradual. The Thames Valley is not a valley of one aspect or geologic stage, but many; the great river and its affluents, and the contents of the bordering gravels and soils sufficiently attest this. Mr. Worthington G. Smith[1] points out that three stages at least in the manufacture of palæolithic flints are traceable, ranging from the crudest to delicate tools of beautiful fabrication.

Coincident with the river earths above referred to, is the ancient peat of Lexden, near Colchester, where the Rev. O. Fisher obtained so many traces of mired and mud-bound Mammals, and an Insect fauna of trans-pyrenean growth.

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[1] *Nature*, xxvii. p. 270.

The fauna of the "Mud Deposit" at Selsey, unfortunately so seldom visible, is exceedingly rich, as is well known, in shells of this age and character. The gravel beneath it is rich in land shells, but so rarely viewed as to be almost unknown. As described elsewhere by myself, I have taken from the mud bed 140 species of shells; of these about 30 do not come north of the Channel Islands or the north of Spain, eight being exclusively Mediterranean forms.

This extension northwards of southern types is visible very notably in the Middle Sands of the North-West of England and Wales, in the Shropshire and Severn gravels, etc. Undoubtedly all these are not of one age, but belong to various periods of the great submergence, as already indicated for the Scottish fauna. The given fauna from these beds is rich, almost too rich, for there is a shrewd suspicion that all the species quoted are not genuinely native, especially when obtained from the workmen. Many quarrymen unhesitatingly bring recent *Naticas* and other species, some with Confervæ on them, as the product of the soil. Mr. Darbishire, Mr. Maw, and myself in a small way have found this, even to the offering of the pearl oyster and other West Indian species.

Apart from this, the beds exhibit *Venus Chione* and other southern shells (and in Ireland *Woodia digitaria*) at higher latitudes than those they are now found living in. The finest and most instructive series, because almost every specimen has been obtained under the supervision of the owners of the gravel pit from whence they were exhumed, and preserved with great care, is that in the possession of the Misses ffarrington, of Worden, Lancashire, in which every species known to the N.W. gravels is contained with many others confined to this pit alone. When, by the kindness of the Misses ffarrington, I had the pleasure of working out the entire series, I found that from 130 to 140 species were represented, and it was not only in the number of southern species, but the southern exuberance of form and sculpture put on by such shells as *Murex erinaceus*, still with us, that testified to the extension northward, and the consequent indication of the southern climate that these showed.

Western currents were at times probably prevalent, since the finding of a West Indian Olive (*O. jaspidea* apparently from Strickland's drawing) and *Bulla ampulla*[1] in the Severn drift implies as much.

I can identify only two deposits in the West of Scotland with this series—Garvel Park and Loch Gilphead, with perhaps Lochaber. The presence of *Rissoa cancellata* and *R. striatula* (the latter only known fossil elsewhere at Selsey), so far removed from their present locality, is remarkable. The "head" over the Portland Beach and the Crystalline Stalagmite above the Cave Bear breccia of Kent's Hole correspond to this open-air earlier deposit.

HESSLE GRAVELS, ETC.—As the first portion of the Interglacial series culminated with the deepest submergence of the North and North-west, so the second part commences with its re-emergence. It is understood that depression is more pertinent to accumulation than is elevation; hence there is little to wonder at that marine life in this stage should be so much less active in appearance than in the preceding period; and nearly all deposits, whatever height they may occupy, belonging to this stage, have been deposited in shallow waters. Present elevation goes for nothing: for example, the living zone of *Saxicava Norvegica* is from 30 to 90 fathoms, and of *Thracia convexa* 4 to 70 fathoms, yet they occur between tide marks on the same level on exactly opposite sides of Scotland, namely, at Bute and the Frith of Forth.

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[1] Mr. Mackintosh, I think, is not very favourable to Molluscan evidence. I am afraid he is hardly a fair judge, as he divides this species into two genera.

A few of the Scotch shell clays belong to this stage, but the non-Arctic shell-beds are chiefly of post "minor glacial" or Neolithic age, certainly those in which *Pecten Islandicus, Tellina calcarea*, and *Astarte borealis*, species still living within easy reach of our coasts (as in Faroe and Norway), are conspicuously absent.

The Marine Gravels of March and Hunstanton below the Fen Peats, and those of Kelsey Hill in the north, and Chislet in the south, belong to this era, the association of *Corbicula* and fluviatile species with marine forms in the two latter being very noticeable, indicating beyond any doubt that marine conditions again prevailed in the North Sea. The March gravels may be of a slightly earlier age, equivalent to the Barnwell freshwater gravels; they cannot be far away.

This epoch is the so-called palæolithic or rough stone implement age of Man, and the prevalence of rough-shapen tools from Peterborough southwards, and their absence together with that of the accompanying Mammalia in Wales, Scotland, and Ireland, affords a fair inference that these places were under water at the time. As a general rule, the more advanced manufactured weapons are in the newer deposits; but, just as Dr. Schliemann found at Troy a Bronze people, succeeded by a Neolithic one, so inferior tools occasionally are *supra* the better-class weapons. Stratigraphically they must be received with caution.

In order of time the fauna of the Bedford Ouse and Thet valleys, the Somerset caves, the Upper Thames gravels, and the Kirkdale and Settle[1] caves, in which Reindeer are few or absent, seem to precede the Fisherton gravels with Marmot, and the Windsor, Rugby, Windy Knoll, and Gower Caves in which they are more plentiful, the Cave earth of Kent's Hole and Cresswell Crags with bone harpoons evidently being the most advanced of all. Professor Prestwich's suggestion that the Hippopotamus was fitted for a more northern climate than it now inhabits seems to be irrefutable, since it is found associated with remains of species widely separated from it now in space and climate. Such separations among old associates are common enough among the Mollusca. Taking Butley again for an instance, of shells which in life were associated, and are now found side by side fossil, *Gastrana laminosa* is Natalese, *Tellina obliqua* Japanese, *Fusus altum* North Cape, *Admete viridula* Greenlandic.

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[1] The supposition that the lower cave earth here is Preglacial will not bear investigation.

Much yet remains to be learnt about the migration of the Mammalia. The Musk Sheep and Glutton in the Forest Bed again reappeared, when a colder period was setting in again, in company with the Northern Lynx and Arctic Fox. But Mr. Howorth has pointed out that rain and damp are the main agents in the delimitations of range of the Reindeer and Musk Sheep, the fresh skulls of the latter occurring at lower latitudes than it now occupies. Prof. Boyd Dawkins has so thoroughly entered into this branch of Palæontology, that I prefer leaving such questions to him.

The Mundesley river bed may probably belong here. The *Hydrobia marginata* (*Belgrandia nana*, Sandb.) and *Elephas antiquus* correlates it to this stage, and if so the presence of the little Chelonian *Emys lutaria* may place the fluviatile deposit at Wretham Mere, Norfolk, with it. I take it that many of the caves just referred to were inhabited, without cessation, during the following minor glaciation, from Yorkshire southwards.

I have lately obtained from the pebble beds overlying the London Clay close to Minster, Sheppey, a flint implement. The two pebble or gravel beds were probably continuous originally.

The Implement gravels of Herne Bay and the South of Hampshire, and the thick yellow clay with large southern erratic rock masses overlying the Selsey mud bed, must be placed here. This clay boulder bed is too often confused with the angular marine gravel above. This gravel I may say helps to form the mass of shingle on the beach, *but* the shingle is *not* composed only of this fall or talus, but is augmented by a large accession of rolled pebbles of all ages, travelling from the westward, a fact often lost sight of.

To this latter half of the Interglacial period I consider the Somme and Seine gravels belong, not to the earlier Thames (Crayford) portion. The tuffs of Cannstadt and of Moret in the Seine Valley will probably give the Flora of the time.

THE MINOR GLACIATION.—Such period will include the Hessle Boulder-clay of Yorkshire, the Upper Boulder-clay of the N. West and Ireland, and probably some of the fossiliferous beds of Scotland, like Paisley and Kilchattan, not possessing so glacial a character as the earlier Fife and Bute beds.

In Lancashire and Westmoreland alternations are not uncommon, peat containing Mosses, Beetles, etc., not being very rare, the marine fauna in the clays, as in those of the low-lying Caithness lands, mostly being fragmentary and derivative. In the south its influence is chiefly felt in the "trail" Löess, Brick-earth, and Contorted Gravel in the Thames Valley Beds and Tolland's Bay; and to this age I am disposed to refer the raised beds on the Sheppey and Pegwell Bay Cliffs, and the long stretch of marine detritus and gravels extending from Brighton to Portsmouth, at all heights, from nearly sea-level to upwards of 200 feet.

The final relics of this era are the Moraines, Eskers, and Kames, chiefly occurring in Ireland and the North, the Lancashire Shirdley Hill Sands and the Nar Valley. The numerous raised marine beds in Devonshire and Cornwall may be referred to here, together with the Selsey superficial Brick-earth and the Brighton "Elephant" bed. The often-quoted deposit at Copford in Essex, and another containing a similar fauna, with flint flakes, at Stroud, Gloucestershire, 650 feet elevation, belong to this stage, some of the species being living known only in Yorkshire and far-distant places. Since the paper on the Copford beds was written by the late Mr. John Brown, the beds, although visited, I cannot find to have been practically worked by any one except myself, Mr. Dalton's memoir being mainly a recapitulation of Mr. Brown, *plus* sundry errors.

Will Mr. Dalton kindly say *where* Mr. S. V. Wood states that "three of the Helices from the Shell Marl no longer live in England," *i.e. H. ruderata, H. incarnata,* and *H. fruticum*: of the many thousands of Copford shells I have had in my hands, I have never seen one of the latter, and Mr. Wood's figure, as already mentioned, is that of a Stutton specimen. Mr. Wood further remarks that the *H. incarnata* requires confirmation, and he does not say in what bed the *H. ruderata* was found, simply giving Copford. My experience of the Marl is that very few shells, except freshwater species, are to be found in it, and Mr. Brown particularly observes that it is only where the marl passes into sandy clay at the sides, that they abound, and in the peat. Dr. Gwyn Jeffreys speaks of the *H. fruticum* as at Copford; the reference, he told me afterwards, was under a misapprehension of a remark of mine, that I had found the shell in England elsewhere than at Stutton. Sir C. Lyell, "Student's Manual," uses the same words as Mr. Dalton, but the account of Copford given by Sir Charles is inaccurate.

I have been a little more prolix than perhaps necessary, because *H. fruticum* belongs to a group of shells pertinent to an age long antecedent to the Copford peats, and the deposit is a typical one, often-quoted but so seldom correctly, that it is quite as well that an error should be set right if possible. Curiously enough, Mr. H. B. Woodward (Geol. England and Wales, p. 333) makes the blue clay beneath the marl to be the source of the Molluscan fauna. From this clay I obtained teeth of Rhinoceros, and a nearly complete set of teeth of a small deer, of which the whole skeleton was found.

Submerged forest and peat beds of this age may be occasionally seen at Torbay, Anglesey, and beneath the Carse Clays of Falkirk, and the Lothians, and the Buttery Clay of the Fens. Such peats as yield Elephant remains may be safely placed here. There is no improbability in supposing that the Mammoth lived on throughout the minor glaciation, since we find his remains in the Reindeer period in Kent's Hole, the two periods being, if not as they may probably have been, coeval, yet certainly closely, together in time; and there is every reason to believe that the Megaceros lived in Ireland long after its extinction in England, and that the Reindeer in Scotland was a still later survival.

The Bovey Heathfield Clay with *Betula nana* and Northern willows is, I think, an inland bed of this period; but it is possible that, like the *Cratægus pyracanthus* and others obtained from Grays Thurrock by Mr. Prestwich and *Pinus sylvestris* by myself, the flora belongs to the period succeeding the major glaciation.

The next or Neolithic stage corresponds with the formation of the 25 feet Raised Beaches of Scotland, comprising much of the ground bordering the Clyde, especially about Glasgow, in which *Tellina calcarea*, *Leda pernula* and other boreal shells appear for the last time in Britain. Some of the beds in this district may be newer still, as in various parts of the town of Glasgow many canoes have been exhumed, from the large canoe dug out by fire and stone, a beautiful weapon being found in one of them, to another in which a cork plug formed part of the equipments, and a well-made clinker-built boat with metallic (iron) fastenings.

The Carse Clays of East Scotland, and the Buttery Clays, or Fen Silts of Lincolnshire and Cambridgeshire; the Megaceros Peat and Bogs of Ireland, the Fen Peats with polished implements; and most of the submerged forest or tree patches skirting the coast, many west country, Scotch and Irish, caves, as Hoyle, Perth, Chwaren, Cefn, and a portion of the Settle Cave, Yorkshire, Oban and Kirkcudbright all fall in this period, but so gradually pass up into the more recent stage that an actual line of demarcation can seldom be drawn.

In these notes I have said but little about Ireland, having entered fully into the subject in a prior communication; it will suffice to say here that every observation made then is fully applicable now, and varies nothing from the lines worked upon above.

The latest deposits comprise the low level beaches in which the fauna is still existing, of which Belfast and Largo Bays, and Portrush furnish good examples, and the Scrobicularia clays and marine beaches in marshy places, as the Burtle beds of Somerset, from whence the sea has been comparatively speaking only recently excluded, the Alluvial flats of Lancashire, and the whole series of intercalated silts, clays, and peats of Somerset and Cornwall, the silts of tidal rivers, the now forming sandbanks and shingles of the coast-lines, the blown sands of Antrim with flint flakes, and of Galway and Cornwall, containing Helices of types (*H. nemoralis* in particular) of a size and structure now unknown, the Megaceros peat bogs and underlying marls of Ireland, and the forest and surface peats of Walthamstow, Newbury, Hull, Lincolnshire and Cambridgeshire, the Caves and Midden deposits of Richmond in Yorkshire, Scotland, and Ireland, and of Settle and Heathery Burn, the subaerial shell beds of the Isle of Wight and elsewhere, and the tufaceous marls formed by incrusting springs in Limestone districts.

All of these are due to such agencies as have been in ceaseless operation since the Bronze dolichocephalic man came into Britain. In Ireland there is every reason to suppose, and probably in the North of Scotland also, that stone implements were in use to a much later period than in England.

It would greatly facilitate the study of the later beds if authors would, instead of quoting in their lists "bones of birds or fish, elytra of insects," endeavour to ascertain what they are. Many species are lost to science for want of such determinations. A list of peat insects, and another of the plants absolutely found in (I do not mean a list of those living which make it) the peat are a great desideratum.

In the foregoing notes I have endeavoured to classify the principal deposits which throw any light upon the succession of the later deposits of our country, and by piecing the fauna and flora together to show that, beyond the vast cessation of life during the great or major glaciation, the succession of organic forms is one without violent alterations, or necessitating alternate cold and hot periods. There can be little reason to fear that ultimately a sequence of these varied deposits and their contents will be established. The fuller the lists are made, the sooner such a to-be-wished-for conclusion will be arrived at.

REVIEWS.

I.—ABHANDLUNGEN ZUR GEOLOGISCHEN SPECIALKARTE VON ELSASS-LOTHRINGEN.

EIN BEITRAG ZUR KENNTNISS DER ELSÄSSER TERTIÄRS. Von Dr. A. ANDREÆ. Mit 12 lithographirten Tafeln, 2 Kartenskizzen, und 10 Zincographien. Band II. Heft. III. 1884.

DER DILUVIALSAND VON HANGENBIETEN IM UNTER-ELSASS, seine Geologischen und Palæontologischen Verhältnisse und vergleich seiner Fauna mit der recenten Fauna des Elsass. Von Dr. A. ANDREÆ. Mit 2 photographischen Tafeln, einem Profil und fünf Zincographien. Band IV. Heft. II. 1884.

MEMOIRS FOR THE SPECIAL GEOLOGICAL MAP OF ALSACE-LORRAINE. A Contribution to the Knowledge of the Tertiary Strata of Alsace. By Dr. A. ANDREÆ. pp. 351, 12 4to. plates, 2 maps, and 10 zincographs.

THE GEOLOGICAL AND PALÆONTOLOGICAL RELATIONS OF THE DILUVIAL SAND OF HANGENBIETEN IN LOWER ALSACE, and a Comparison of its Fauna with the present one of Alsace. By Dr. A. ANDREÆ. pp. 90, 2 photographed plates, 1 profile, and 5 zincographs.

IN the first of these memoirs a detailed description is given of the Tertiary strata of Alsace. The lowest beds, which belong to the Middle Eocene, are freshwater limestones distinguished by the characteristic *Planorbis pseudammonius* and containing teeth of *Lophiodon* and other mammals. Above these are sandstones with plant-remains, and then thick beds of dolomitic limestones with *Melania* and other freshwater genera, referred to the Upper Eocene. Beds of Oligocene age are very extensively developed in Alsace, and, on account of their containing petroleum and bitumen, are economically important. Borings have been made in them to a depth in some places of 300 mètres without penetrating through them. The lowest Oligocene strata consist of beds of gypsum, apparently of brackish-water origin; these are succeeded by petroleum-bearing marls and sandstones, and then marine deposits of sand, marls, septarian-clays with numerous foraminifera, and fish-bearing shales, which belong to the Middle Oligocene. The Upper Oligocene deposits are marine or strongly brackish marls, sandstones and conglomerates.

The fauna and flora of these Tertiary deposits are very carefully described and most admirably illustrated in the accompanying atlas of plates; the figures have been drawn by the author's own hand. Numerous new species of freshwater mollusca and of foraminifera are introduced.

The second memoir consists of a detailed description of a section of diluvial or Post-Tertiary sands and marls exposed in the Rhine valley at Hangenbieten, a short distance from Strassburg. The total thickness of the deposits is about 15 mètres. The uppermost stratum is a typical non-stratified Loess, containing land-shells exclusively, which the author regards as Post-Glacial. Beneath this is a Loess of nearly the same petrographical character as the bed above, but containing freshwater as well as land-shells. Next below is a reddish sand—known as renovated Vogesen sand—which contains 17 species of land and 13 of freshwater shells, and in places remains of Mammoth and Reindeer. The author places this, and the Loess above it, as probably of Glacial age. Under the Vogesen sand are concretionary marls, in which the freshwater molluscs are more numerous than the land forms, and these are succeeded below by fluviatile sands in which 79 species of molluscs (48 land and 31 freshwater) have been discovered. Four of these are entirely extinct species, and many others have altogether disappeared from the district. A still lower bed of sand with but few fossils in it forms the base of the section. These lower beds are regarded as of Interglacial age.

The author furnishes a table in which a comparison is made of the fauna of the Hangenbieten section with that now existing in Elsace and the district of the Upper Rhine, and with that of Mosbach near Biebrich and of Mauer near Heidelberg. Descriptions are given of some new forms, and all the species are shown with remarkable clearness in the appended photographic plates. G. J. H.

II.—Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura. Von Dr. Rüst, in Freiburg I/B. Palæontographica, Band xxxi. Mit Tafel i.—xx. (Cassel, 1885.)

Contributions to the Knowledge of Fossil Radiolaria from Rocks of the Jura. By Dr. Ruest, of Freiburg. Palæontographica, vol. xxxi. pp. 51, with 20 plates.

With the exception of a few species of Radiolarians from the Upper Chalk of North Germany described by Zittel, and 18 species from the Lower Lias of the Tyrol, which Dunikowski has named and figured,[1] scarcely anything has hitherto been known of fossil Radiolaria from strata older the Tertiary, and these minute siliceous organisms have been regarded as forming but an insignificant part of the fauna of the older rocks. The present memoir, in which 234 different species of Radiolaria belonging to 76 genera, are described from Cretaceous and Jurassic strata, furnishes good evidence that they flourished as abundantly and in as great variety of form in the seas of these periods, as in those of Tertiary and recent times.

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[1] Dr. G. C. Wallich has lately called attention to the occurrence of Radiolarians in the cavities of flints from the Upper Chalk of Surrey, but they have not yet been described. Ann. and Mag. Nat. Hist. 5th ser. vol. xii. p. 52, 1883.

From the Middle and Upper Chalk Dr. Rüst discovered but few Radiolarians, they were however abundant in Neocomian limestone at Urschlau in Upper Bavaria. The so-called *Aptychus*-Schiefer from Urschlau and several other places in the Tyrol were found to be very rich in well-preserved specimens. They also occur in the Jasper and Chert from rocks of "Tithon" age in the Upper Alpine Jura at Allgäu, near Murnau, and other places in the Tyrol. In the red jasper the Radiolarians are so abundant that their shells are in close contact in the rock, whilst in the chert on the other hand they are comparatively rare. In this latter material the Radiolarians are replaced by sponge-remains and foraminifera, and many dark beds of chert are stated to consist of bedded masses of scattered sponge-skeletons (in the same manner as turf consists of remains of *Sphagnum*), with a few scattered Radiolaria between. The red jasper however, may be compared to a Radiolarian mud, like that brought up from the greatest ocean depths by the Challenger expedition.

Fragments of this jasper, containing the same species of Radiolarians, are found in gravels all over West Switzerland, and they are most abundant in the Nagelfluh of the Rigi and the conglomerate of Uetliberg.

In Hungary also, in chert and jasper of the age of the Tithon, the Malm, and the Middle Dogger, Radiolarians were discovered.

The author obtained his richest harvest of Radiolarians from Coprolites occurring mingled in beds of iron ore, which are largely worked at Ilsede, near Peine, in Hanover.[1] The ore-deposits rest on Gault-clay and are overlaid by Cretaceous marls, but neither in the rocks above nor in those below were Radiolarians discovered. The coprolites in these beds are round or cylindrical in form, and vary from the size of a lentil to that of a goose's egg, they are largely employed for making superphosphate. The age of these coprolites was determined by the occurrence with them of two species of *Ammonites*; one, *A. torulosus*, Zieten, characteristic of the Lower Dogger, and the other, *A. caprinus*, Schlot., of the Upper Lias. The author investigated coprolites from the Lias of Lyme Regis and Gloucester, which corresponded closely in character with those from Ilsede, but only in those from Gloucester were some few Radiolarian remains discovered.

Further, in red limestones of Middle Lias age, and in Chert of the Lower Lias in Hungary, Radiolarians were also present.

The author calls attention to the fact that whilst in Jurassic and Tertiary strata a Radiolarian-fauna is so largely developed, in the intervening Cretaceous beds hardly a dozen species have been found, and it seems also to be a general rule, that where sponge-remains and foraminifera are abundant, Radiolarians are of rare occurrence, and *vice versa*.

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[1] The geological horizon of these coprolitic iron-ore beds appears to be the same as that of the Cambridge Greensand; and it is worthy of notice that Radiolarians have been discovered by Prof. Sollas in the Coprolites of this latter deposit, but they have not yet been described. See Quart. Journ. Geol. Soc. vol. xxix. 1873, p. 78.

With the exception of two, apparently extinct, genera (*Podocapsa* and *Salpingocapsa*), all the Jurassic Radiolarians can be included in the genera set forth in Hæckel's Prodromus Systematis Radiolarium. As a rule these older forms are more regular, simpler, and somewhat larger than the recent, and they have less adornment and armature.

The species described are clearly shown in 18 of the accompanying plates; most of the figures are drawn to the scale of 300 diameters; on plate xix. are figures of plant-spores and other doubtful minute objects met with in connection with the Radiolarians, and on plate xx. some of the spicules of sponges are figured. These belong to three, if not four, of the principal divisions of siliceous sponges, and include some very peculiar forms. One of these resembles the so-called plumose (Tannen-baum) flesh-spicule of certain recent Hexactinellids, and is the first hexactinellid flesh-spicule which has been discovered in a fossil state. It would have been more satisfactory to know the scale on which the spicules have been drawn.

One need hardly state that this memoir is a very important addition to our knowledge of the microfauna of the Jurassic strata, and is strong testimony of the patient industry and zeal of the author in discovering these minute organisms from such various sources. We are promised future notices of Radiolarians from Triassic and Permian strata, which will be looked for with much interest.

G. J. H.

III.—GEOLOGY, CHEMICAL, PHYSICAL, AND STRATIGRAPHICAL. By JOSEPH PRESTWICH, M.A., F.R.S., F.G.S. In Two Volumes. Vol. I. CHEMICAL AND PHYSICAL. Royal 8vo. pp. xxiv. and 478, with three Chromo-lithographic folding Maps, three folding Coloured Sheets of Sections, and 218 Woodcuts. (Oxford: At the Clarendon Press, 1886.)

THIS is an epoch marked by the production of geological text-books. Year after year, a steady flow of manuals issues from the press, and one prophet after another arises, each with some special claim upon the attention of teachers and students.

Among the vast array of really good books the treatise just issued by the Clarendon Press deserves our special notice, coming as it does from the pen of Prof. Prestwich, one of the oldest living exponents of the science, whose papers upon the Tertiary Geology of the South-East of England, of France and Belgium, and upon the Geology of Coalbrookdale, etc., may be found scattered *broadcast* through the Transactions, Proceedings, and Quarterly Journal of the Geological Society, while others upon cognate subjects adorn the Philosophical Transactions of the Royal Society and the pages of the GEOLOGICAL MAGAZINE.

The volume before us is devoted to Chemical and Physical Geology, and will shortly be followed by a Stratigraphical and Palæontological companion. Three very pleasing features in the present book are the excellency of the paper, the typography, and the illustrations—matters, alas! too often neglected, but having a most vital importance in the success or failure of a work. Three chromo-lithographic folding maps, three sets of folding coloured sections, and no fewer than 218 woodcuts (many of which are specially prepared for the present work) adorn and make bright its pages, and render good service in the elucidation of the author's views.

Professor Prestwich, in his preliminary remarks, observes that among geologists two schools have arisen, "one of which adopts uniformity of action in all time,—while the other considers that the physical forces were more active and energetic in past geological periods than at present."

"On the Continent and in America the latter view prevails, but in this country the theory of uniformity has been more generally held and taught. To this theory I have always seen very grave objections; and I felt I should be supplying a want by placing before the student the views of a school which, until of late, has hardly had its exponent in English text-books." It must be borne in mind, however, that "the doctrine of non-uniformity must not be confounded with a blind reliance on catastrophes; nor does it, as might be supposed from the tone of some of its opponents, involve any questions respecting uniformity of law, but only those respecting uniformity of action."

"I myself have long been led to conclude that the phenomena of geology, so far from showing uniformity of action in all time, present an unceasing series of changes dependent upon the circumstances of the time; and that, while the laws of chemistry and physics are unchangeable and as permanent as the material Universe itself, the exhibition of the consequences of those laws in their operation on the earth has been, as new conditions and new combinations successively arose in the course of its long geological history, one of constant variation in degree and intensity of action."

Prof. Prestwich very properly points out that, for the student, the first object "should be to study the laws to which the materials and masses he has to deal with are subject, and then to consider what may have been their action under varying conditions in past time." With this object the author has divided his work into four parts: "The first, treating of the composition of minerals and rocks forming the crust of the earth; the second, the mode of action of geological agencies under existing and under past conditions: while the third and fourth will treat of the succession of the groups of sedimentary strata and of the life thereof, and of some of the theoretical questions connected with the physical conditions prevailing during former periods of the earth's history." The four earlier chapters up to p. 61 comprise a consideration of the constituents of the Earth's crust, which are enumerated and described, and all the numberless forms of rocks resulting from the varying combination of their constituent minerals are discussed and exemplified.

The mode of action of geological agencies should have commenced at p. 62; but Chapter V. is occupied with an account of the "Order, Place, and Range of past Life." This we venture to think might have been held over and formed a part of Vol. II., in which the Life-history of the Earth will be discussed.

We live in an age of change, and in no department have greater changes arisen lately than in that of Biology. The author has brought together in this chapter a series of tables of classification of each group of the animal kingdom; but as these tables are necessarily by various authors, and of very varying dates of publication, from 1868 to 1883, *some at least* need emendation.

Thus in the classification of the MAMMALIA (p. 79) the Seals, (PINNIPEDIA) have been placed with the Cetacea, whereas they are now universally placed with the CARNIVORA; and the Sloths, Ant-eaters, and Armadillos (EDENTATA), have been placed between the CARNIVORA and RODENTIA, whereas they are now placed next the MARSUPIALIA.

The PROBOSCIDEA, PACHYDERMATA, SOLIPEDIA, and RUMINANTIA are not so arranged by later zoological writers, but they form one great order, the UNGULATA (or hoofed quadrupeds) divided into various sub-orders, as

Sub-order 1. HYRACOIDEA (Hyrax);
„ 2. PROBOSCIDEA (Elephants);
„ 3. AMBLYPODA (Dinoceras, etc.);
„ 4. PERISSODACTYLA (Tapirs, Rhinoceroses, Horses);
„ 5. ARTIODACTYLA (Pigs, Deer, Oxen, and Sheep).

Happily these and other needful modifications can be made in Volume II., which deals with the Life-history of the Earth, and is not yet published.

On p. 69 the MYRIOPODA have accidentally got between the DECAPODA and the CIRRIPEDIA; and on p. 68 *Entomostraca* and *Malacostraca* seem of equal classificatory value with INSECTA, the word CRUSTACEA, which should be the leading one, being subordinated. The ARACHNIDA and MYRIOPODA should not be bracketed together, they are really *widely separated* groups. Neither should the MARSIPOBRANCHII and the PHARYNGOBRANCHII be bracketed together (p. 76). The first embraces the "Hag-fish" (*Myxine*) and "Lamprey" (*Petromyzon*); the second a single form the "Lancelet" (*Amphioxus*), so anomalous as to be by some naturalists relegated to a separate class!

It is, therefore, misleading to the student to bracket these two together with the remark (after "no fossil forms known") "? *Conodonts*"; for if the curious little microscopic bodies called "Conodonts" met with by Pander in Russia and by Hinde in the Cambro-Silurian and Devonian rocks of North America, are fish-teeth, which is very doubtful,[1] they must have belonged to the "Hag-fish" (*Myxine*), and could have nothing to do with *Amphioxus*, which is destitute of teeth or any other hard organs whatever.

But to pass on to the question [Chapter VI. (p. 82)] how "Sedimentary strata are formed by river and sea erosion." Commencing in the truly philosophical 'Lyellian' and 'Darwinian' style to argue from the known to the unknown, we find the author teaching his students "to study the effects of the agencies at present acting on the surface of the globe, in so far as they are of a nature to furnish evidence which may assist in the interpretation of the mode of formation of the sedimentary strata, of the disturbances to which these strata have been subjected, and of the succession of life of which they contain the remains."

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[1] See Quart. Journ. Geol. Soc. vol. xxxv. 1879, pp. 351–368, plates xv.–xvii. Compare these with the odontophore of certain mollusca, *Strombus*, *Cassis*, *Triton*, etc.

Then we have *Rain* treated as a geological agent; the formation of *Deltas*, their age; *River Denudation;* the formation of *Valleys; Drainage-Influences;* the *Cañons of the Colorado*,—illustrated by a page-cut of Marble-cañon and a glimpse at the Dolores cañon.

From this we pass to the consideration of *Marine Action,—the origin of the coast shingle in the English Channel*—illustrated by the famous case of the Chesil Bank—and the cause of the *wear of coasts*, illustrated by the gradual destruction of Lundy Island, an 'outlier' of the old North Devon Coast, the Chalk Cliffs of Brighton, Dover, etc.

In Chapter VII. the subject is continued, and we are invited to consider waste (by chemical solution) in the soluble matter carried down to the sea and into lakes by Rivers; its character and quantity; and the resultant formation of Calcareous strata.

The Organic origin of Limestones is next touched upon, and the presence of soluble silica in Cretaceous and Jurassic strata is adduced as evidence that a very different state of things existed then, to any which obtains in the present seas. May not the soluble silica referred to have been very largely derived from the *subsequent* decomposition of the vast numbers of silioeous sponges which are known to have existed in the seas of the Secondary period? and may not these chemical changes have taken place *long after* the Calcareous muds forming the sediments of these Mesozoic waters had been accumulated and to a great extent solidified?

The author refers to the various *modern Calcareous beds* now forming, such as the shell-limestones accumulating along many coasts like that of Guadaloupe, the Canaries and the Island of Ascension. He next glances at *Deposits in Lakes*, of which the shell-marls always form a most interesting series, often rich in organic remains.

From these the author passes on to consider those strata which owe their present state to subsequent chemical reaction, such as Magnesian Limestone, Gypsum and Rock-salt.

Space does not permit us to dwell longer on this interesting work. The seventeen chapters that follow are not merely a bare compilation from the works of other observers, but Prof. Prestwich is able to bring much of his own original labours in the past to bear upon the subjects under consideration, and so to exalt the work into a far higher position than that of an ordinary text-book.

We hope to come back to its consideration at a future day. A most valuable feature of the book is its excellent Index of 27 pages, of three columns to a page, which renders the contents easily accessible to all, and gives the book a very high place as a work of ready reference.

IV.—MEMOIRS OF THE GEOLOGICAL SURVEY.

1.—THE GEOLOGY OF HOLDERNESS, AND THE ADJOINING PARTS OF YORKSHIRE AND LINCOLNSHIRE. By CLEMENT REID, F.G.S. 8vo. pp. 177. (London, 1885.) Price 4s.

THIS Memoir is devoted to an account of the Glacial and Post-Glacial deposits of the Holderness district, that are included in the area of Sheets 85, 86, and 94 of the Geological Survey Map. The district was surveyed in part by Mr. J. R. Dakyns and in part by Mr. A. C. G. Cameron, as well as by Mr. Reid, who however has a personal knowledge of the entire region.

The Drift-deposits of Holderness occupy an old bay bounded by Chalk hills, a bay whose form is due to the relative hardness of the lower and upper beds of Chalk, the former standing out in the bold headland of Flamborough. The Drift-deposits have been banked up against the old line of Chalk cliffs, in places to a depth of 100 feet, so that while geologically speaking the ancient Bay of Holderness has been preserved, physically speaking it has been obliterated or smothered up.

The oldest Boulder-clay, known as the Basement-clay, is interesting from the occurrence in it of transported masses of sand and clay full of mollusca. These fossiliferous layers have been described under the name of Bridlington Crag; but the view that they are included in the Glacial Drift, advocated by Mr. S. V. Wood, has (with a different explanation) been confirmed by Mr. G. W. Lamplugh and Mr. Reid. It was indeed previously announced in the GEOL. MAG. (Vol. I. 1864), by the late Dr. S. P. Woodward, that the Bridlington deposit can no longer be considered the equivalent of the Norwich Crag, being of an Arctic character, a conclusion which, as Mr. Reid remarks, "subsequent discoveries have only tended to confirm and strengthen." A revised list of organic remains from the Bridlington Crag is now published, and this includes, besides Mollusca, Plants, Foraminifera, Cirripedia, Entomostraca, and Vertebrata. The Vertebrata are probably derived from Crag, Eocene, or older deposits. Remains of Echinodermata and Polyzoa have been found, but these as yet are undetermined. Mr. Reid observes that while the Basement-clay is the lowest bed exposed in the Holderness cliffs, the Chalk is generally about 60 feet beneath the sea-level—hence older Glacial or even newer Pliocene beds may be concealed in places.

Above the Basement-clay, other layers of Boulder-clay, known as the Lower and Upper Purple Clays and the Hessle Clay, are locally to be distinguished. Mr. Reid makes some important observations on the weathering of Boulder-clay, whereby chalky Boulder-clay passes into reddish-brown stony loam.

Associated with the Boulder-clays are marine Inter-Glacial and other gravels and laminated clays. The Inter-Glacial beds have yielded mammalian bones, and a marine fauna indicating a climate that seems to have been little if at all colder than that of the same region at present. A full list is given of the organic remains found at Kelsey Hill, and other places, and a column showing the forms found at March in Cambridgeshire is added. A description of the Post-Glacial deposits and their organic remains, contains the observation that *Felis spelæa* and perhaps *Elephas primigenius* are true Post-Glacial species. The Lion has been found at Hornsea, associated with the Irish Elk, Horse, and Red-Deer, apparently in the ancient deposits of the Mere.

A chapter is devoted to the changes now in progress. The serious loss of land along the coast-line within historic times is well known, and this is clearly illustrated by diagrams or reproductions of charts dating from 1684. Since this period the average rate of advance of the sea has in places been about 2¼ yards a year. In other places land has been gained.

A concluding chapter gives an account of the Economic Geology—soils, brickmaking, etc., with some mention of the Humber Tunnel. The Water-supply is also discussed, and details of a number of Well-sections and Borings are given. An appendix contains a list of works on Holderness.

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2. THE GEOLOGY OF BRIDLINGTON BAY. By J. R. DAKYNS and C. FOX-STRANGWAYS. 8vo. pp. 18. (London, 1885.) Price 1s.

THIS is a brief explanation of Quarter-sheet 94 N.E. of the Geological Survey Map. It includes an account of the Chalk, Glacial and Post-Glacial Beds. Mr. Reid contributes the List of Fossils from the Bridlington Crag.

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3. THE GEOLOGY OF THE SOUTH-WEST PART OF LINCOLNSHIRE, WITH PARTS OF LEICESTERSHIRE AND NOTTINGHAMSHIRE. By A. J. JUKES-BROWNE, B.A., F.G.S. (Parts by W. H. DALTON, F.G.S.) 8vo. pp. 180. (London, 1885.) Price 4s.

THIS is a description of the rocks embraced in the area of Sheet 70 of the Geological Survey Map. The area was chiefly surveyed by the late Mr. W. H. Holloway, other portions being mapped by Messrs. W. H. Penning, W. H. Dalton, and A. J. Jukes-Browne. The rocks include the Upper Keuper Marls, the Rhætic Beds, the Lias, the Oolites from the Northampton Sand to the Kimmeridge Clay, and various Glacial and Post-Glacial deposits.

Detailed descriptions of the strata are given, and the palæontological divisions, with lists of fossils, are duly noted. The junction of the Lower with the Middle Lias is taken at the top of the clays with *Ammonites capricornus*: so that a number of forms regarded as Middle Lias in Dorsetshire are now placed in the Lower Lias. This higher line was adopted by Prof. Judd in the Rutlandshire district, and hence it was desirable to continue it northwards. *Ammonites communis* is noted from the Middle Lias, so that our notions of the value of Ammonites as indices of zones are liable to be shaken. It is remarked that the zones of *Ammonites Humphriesianus* and *A. Parkinsoni* are altogether absent from Lincolnshire, unless the former is represented by the upper portion of the Lincolnshire Oolite.

The Glacial deposits include representatives of the Chalky Boulder-clay, Purple and Hessle Clays, with associated gravels. The large transported masses of Lincolnshire Limestone and Marlstone, to which attention was first directed by Prof. Morris, are described; and Mr. Jukes-Browne regards them as due, together with the Boulder-clay itself, to the agency of coast-ice.

Among the mineral resources of the district, the Lincolnshire Limestone is noteworthy, being largely quarried at Ancaster. Of the iron-ores, that derived from the Marlstone Rock-bed is most important, and it has been lately described by Mr. E. Wilson ("Midland Naturalist," vol. viii. 1885). The gypsum in the New Red Marls at Newark is also extensively worked.

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4. THE GEOLOGY OF ESKDALE, ROSEDALE, etc. By C. FOX-STRANGWAYS, F.G.S., C. REID, F.G.S., and G. BARROW, F.G.S. 8vo. pp. 65. (London, 1885.) Price 1*s.* 6*d.*

THIS is an Explanation of Quarter-sheet 96 N.E. of the Geological Survey Map. It contains an account of the Lias, the Oolites from the Dogger to the Middle Calcareous Grit, and of the Glacial and Post-Glacial beds.

The Upper beds of the Middle Lias, which constitute the Ironstone series, are described in detail. They furnish the well-known Cleveland Ironstone. The Dogger, which occurs at the base of the Oolites, is a variable bed changing from limestone to sandstone, and in places yielding the valuable iron-ore of Rosedale.

In the Lower Estuarine Series, above the Dogger, comes the Eller Beck Bed, yielding marine fossils, which was described by Mr. Barrow in the GEOLOGICAL MAGAZINE (Decade II. Vol. IV. p. 552). Higher up there is a bed of coal which has been worked. The Grey Limestone Series, and the Upper Estuarine Series, the Cornbrash, Kellaways Rock, Oxford Clay, and Corallian Rocks, present many features of interest, and their palæontological contents are duly noted. The Whinstone or Cleveland Dyke is an intrusive dyke of augite-andesite.

The absence of Drift over most of the country now described is remarkable. Boulder-clay extends to a height of about 800 feet in the valleys to the north of the table-land, but is not met with in the interior, nor has any trace been found there of local glaciation. Hence it is concluded that the uplands formed an insular space round which the ice-sheets swept, while these high grounds were not glaciated.

5.—THE GEOLOGY OF THE COASTS ADJOINING RHYL, ABERGELE AND COLWYN. By AUBREY STRAHAN, M.A., F.G.S. (with Notes by R. H. TIDDEMAN, M.A., F.G.S.) 8vo. pp. 73. (London.) Price 1*s.* 6*d.*

THE area here described is included in Quarter-sheet 79 N.W. of the Geological Survey Map, and was originally surveyed by Messrs. W. T. Aveline, W. W. Smyth, and A. C. Ramsay. The ground having been re-surveyed on the scale of six inches to a mile, by Messrs. Tiddeman and Strahan, the map has been revised, and this Explanation published.

The rocks include Wenlock Shales, Carboniferous Rocks, Bunter Sandstone, Glacial Drifts and Post-Glacial Beds. Between the Basement-beds of the Carboniferous rocks (red conglomerates, etc.) there exists "one of the greatest unconformities to be met with in the British Isles," the Silurian strata having been cleaved, contorted, and denuded before the overlying rocks were laid down. In the pebbles of these Carboniferous conglomerates many Ludlow fossils have been found.

The principal formation described is the Carboniferous Limestone, from which many fossils have been obtained. The Millstone Grit is interesting, from the remarkable development of chert met with. Mr. Strahan remarks that unlike the bands and nodules of chert in the Carboniferous Limestone, this chert is probably a siliceous sediment of extreme fineness; for not only is it well stratified, and evenly laminated, but, by a gradual lithological change, it passes horizontally into a fine-grained quartzose sandstone, with bands of chert, and finally into a quartz grit with quartz pebbles, in which chert bands are quite subordinate. The Lower Coal-Measures and Trias are briefly described. The whole of the low ground and the flatter parts of the high ground are overspread by Drift-deposits consisting of Boulder-clay and Gravels. The Post-Glacial Beds comprise Calcareous Tufa, Peat and Alluvium, and Blown Sand. In a Chapter on Economic Geology accounts are given of Lead and Zinc Ores, Hæmatite, etc. An Appendix contains a list of works on the Geology, etc., of Denbighshire and Flintshire, by Messrs. Whitaker and Strahan.

V.—The Geological Record.

THE "Geological Record" was founded in 1874, with the object of publishing a yearly register of all publications relating to Geology, Mineralogy, and Palæontology. The volumes for the years 1874 to 1878 have appeared with brief abstracts: that for 1879 is in the press. These have been prepared under the editorship of Mr. William Whitaker, B.A., F.G.S., who has spared no pains, amid many disappointments and delays, to render the volumes as complete as possible.

The British Association gives a grant in aid, sufficing for some assistance, the correction of proofs, etc. The greater part of the work, however, is done by geologists who give their help gratuitously. There are no funds available for the purchase or exchange of publications. Hence the Editor is to a very large extent dependent on the exertions of voluntary assistants. No doubt the delays have tended to damp the ardour of many who have laboured on behalf of the Geological Record.

Mr. Whitaker has now retired from the position of Editor, and Mr. William Topley, F.G.S., Assoc. Inst. Civil Eng., has bravely undertaken to carry on the work. In order to bring the "Geological Record" up to date, he has decided to issue one volume for the five years 1880–1884 with titles only, and to resume the abstracts for the year 1885.

From a circular just issued we learn that the present Editor would gladly welcome further assistance, and would be especially thankful if authors would forward to him brief notices of papers, etc., appearing in the publications of provincial societies, which are often not easily obtained in London. Authors, secretaries of societies, and editors of geological publications would also greatly assist the work by forwarding copies of their publications to the Editor of the "Geological Record," 28, Jermyn Street, London, S.W.

VI.—PROCEEDINGS OF THE CHESTER SOCIETY OF NATURAL SCIENCE. No. 3. 8vo. pp. 134; 9 Plates. (Printed and Published by Giles Griffith, Chester, 1885.)

THE present volume includes fifteen papers upon various subjects read before the Society from 1878 to 1884. Of these papers eight are of geological and palæontological interest.

The first is by the President of the Society, Prof. T. McKenny Hughes, M.A., F.G.S., entitled "Notes on the Geology of the Vale of Clwyd." As to the merits of this paper it is sufficient to say that it is upon a subject which is peculiarly the author's own. It is illustrated by eight plates (23 figures), and is a most valuable contribution to the geology of the district. After a short introduction, the rocks found in the Vale of Clwyd are briefly described in order, beginning with the oldest or Bala series, and passing upwards to the recent Cave-deposits. Under each formation we have a list of its chief fossils and peculiarities of structure and comparisons with the same horizons in other districts, along with valuable local notes as to where the most interesting sections may be most easily observed. There is a valuable note "On the Weathering of Mountain Limestone," explaining in a very clear manner the formation of those caves with which we are all so familiar in limestone districts, and at the same time mentioning places where the effect of the weathering may most easily be observed. It is impossible to over-estimate the importance of such a paper as this to local geologists; for, rich as it is in facts and details, it is still richer in suggestions which need for their working out the time and patience of the local geologist; and we do not doubt that this paper by the President will originate much good work, which will appear in future volumes of the Proceedings.

The next paper is by Mr. Aubrey Strahan, M.A., F.G.S., on "The Denudations of North Wales." This is an admirable paper by one who for a long time was associated with the Society as Honorary Curator of the museum, when he was engaged in the Geological Survey of the district. In the present paper Mr. Strahan proposes to examine the evidence, afforded by examples in this district, of the fact that "while existing lands, being themselves chiefly formed of stratified marine material, occupy the sites of seas of former geological periods, on the other hand these seas overspread the ruins of still more ancient continents." This paper is one which all local geologists should read, and all the places mentioned will well repay a fresh visit in the new light thrown on them by Mr. Strahan's paper.

Then follows a paper by Professor Judd, F.R.S.—"A Problem for Cheshire Geologists." The paper is an abstract of one read before the Society, Nov. 27th, 1878. Professor Judd shows that the strata of the various formations were originally much more widely distributed over the British Islands than they are at the present day, and that the breaks in their continuity must have been caused by subsequent denudation. Not only is this true in the case of the older Carboniferous rocks. It is probable that before the deposition of the Tertiary rocks, the greater part of the British Islands was "buried under the thick strata of the Liassic and Oolitic age, and that a great winding sheet of Chalk enveloped nearly the whole of the country." The greater part of the Secondary strata has now been removed by denudation, and much interest naturally attaches to these isolated patches or "outliers." One such patch is in the district lying between Audlem and Wem, and the problem for Cheshire geologists, writes the Professor, is—(1) To determine the exact extent and limits of the outlier. (2) The relations to the surrounding strata. (3) The nature, thickness, and fossil contents of the outlier. We hope Cheshire geologists are now on their way at least to the solution of this geological problem.

We now come to a very short note on "Traces of an Interglacial Land-surface at Crewe," by that veteran geologist Mr. D. Mackintosh, F.G.S. These traces the author supposes he has found in an exceedingly fine and more or less flexible kind of leaf-clay which he discovered at the Crewe Railway Station.

The next paper is one by Mr. W. Shone, F.G.S., on "The Silting-up of the River Dee: its Causes." As an introduction to his paper, Mr. Shone first gives us some account of the river both in historic and in prehistoric times, with some interesting quotations from early writers. Then follow a number of details—the result of much patient observation—as to the rate of flow of the tide up the river, and its rate of outflow back again to the sea. Mr. Shone attributes the silting-up of the river to several causes combined, the chief of which are—the tapping of the water at Llangollen for the canal; the building of the causeway, and the reclaiming of the land on Sealand. We cannot help thinking that, after all, the real cause of the silting-up of the Dee is the extremely small amount of fresh water which comes down from Bala Lake. We know that in dry seasons, with the exception of a small quantity of water which passes over the mill, no water at all finds its way over the Causeway, and of course there would be just the same flow so far as volume is concerned, whether the Causeway were there or not. But the upper part of the river instead of being practically a long lake would be a shallow muddy river, were the Causeway removed.

Three papers follow by Mr. A. O. Walker, the first two on entomology and the third on a meteorological subject. The first, on "Climatic Causes affecting the Distribution of the Lepidoptera in Great Britain." The second is "A List of the Macro-lepidoptera of the District." The third by Mr. Walker is on the "Climate of the Cheshire District in Relation to Fruit-growing."

Dr. Stolterfoth follows with an account of his work at "Surface Dredging in the Dee." This paper is especially interesting to microscopists, as it deals entirely with diatoms and the lower forms of animal life, and shows how very abundant are the lower forms of life in the estuary of the Dee. Then four papers by Mr. G. W. Shrubsole. The first a note on the Polyzoon, "*Glauconome disticha*, from the Bala beds of Glyn Ceiriog." In this paper Mr. Shrubsole describes a new genus of Polyzoon, which for some time has been regarded as identical with *Glauconome disticha* from the Dudley beds. The new name proposed is *Pinnatopora Sedgwickii.* There is a list of land and freshwater shells compiled by Mr. Shrubsole "from local collections sent in from time to time at the annual conversaziones." It consists of 93 species and 19 varieties, and is followed by a few interesting remarks. A paper "On the Occurrence of *Calcisphœra* (Williamson) in the Mountain Limestone of the Eglwyseg rocks, near Llangollen," by Mr. Shrubsole, follows next. In this paper Mr. Shrubsole has brought together in a clear and concise manner all that is known about these curious fossil Rhizopods, about which there has been so much dispute as to whether we should classify them with the Foraminifera in virtue of the calcareous material of which their remains are composed, or with the Radiolaria in virtue of their minute structure. There is also a brief note by Mr. Shrubsole on the occurrence of *Venus mercenaria.* Then follows a paper, by Mr. Ruddy—"A List of Caradoc or Bala Fossils, found in the Neighbourhood of Bala, Corwen, and Glyn Ceiriog"—one of the most valuable in this number of the Proceedings, giving evidence of years of patient work, and which no one who wishes to work at the Bala beds can possibly afford to be without. The last paper is a botanical one by Mr. J. D. Siddall, on "The American Water-weed, *Anacharis alsinastrum*, Bab.," illustrated by a carefully drawn plate.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Dec. 16, 1885.—W. Carruthers, Esq., Vice-President, in the Chair.—The following communications were read:—

1. "Old Sea-beaches at Teignmouth, Devon." By G. Wareing Ormerod, Esq., M.A., F.G.S.

The author stated that while old records show that no important changes have taken place in the level of the Teignmouth district during the historical period, the excavations made in recent drainage-operations in the present year showed the existence of at least two series of beaches. The oldest sea-beach, which is a few feet above the present sea-level, was partly washed away and then covered up by later deposits exhibiting evidence, in a number of delicate bivalve shells in an unbroken condition, of having been deposited in a calm sea.

2. "On the Gabbros, Dolerites, and Basalts of Tertiary Age in Scotland and Ireland." By Prof. John W. Judd, F.R.S., Sec.G.S.

In previous papers published in 1874 and 1876, it has been demonstrated by the author that there exist in Scotland and in Hungary igneous rock-masses presenting the most perfectly crystalline characters and belonging to the Tertiary period. It was further shown that such highly crystalline, plutonic rocks are seen passing insensibly into volcanic rocks of the same chemical composition—gabbros into basalts, diorites and quartz-diorites into andesites, and quartz-andesites and granites into rhyolites—the lavas in turn graduating into the perfectly vitreous types known as tachylytes and obsidians.

The present paper deals with the basic rocks of Western Scotland and Northern Ireland, which are shown to exhibit the most marked analogies with rocks of the same age in the Faroe Isles and Iceland; these facts lend strong support to the doctrine of the existence of petrographical provinces. The Tertiary age of the Scotch and Irish rocks is placed beyond dispute by the fact that they overlie unconformably the youngest members of the Cretaceous system, and are interbedded with stratified deposits of Lower Tertiary age.

With regard to the nomenclature of these rocks, the identification of the more crystalline forms with the gabbros, which was made by Zirkel and Von Lasaulx, is supported; while the use of the term "dolerite" as a convenient one for the connecting links between the gabbros and basalts is advocated.

Of the original minerals contained in these rocks, plagioclase felspar (ranging in composition from anorthite to labradorite), augite, olivine, and magnetite, are regarded as the essential ones; while enstatite, biotite, chromite, picotite, and titanoferrite are among the most frequently occurring accessories. It is shown, however, that these original minerals may belong to different periods of consolidation. The Secondary minerals are very numerous, including quartz, epidote, zoisite, hornblende, serpentine, and zeolites, with many other crystallized and uncrystallized substances. There are remarkable variations in the relative *proportions* of the original minerals in different examples of the rock; and by the complete disappearance of one or other of the constituents, the gabbros are sometimes found passing into picrites, eucrites, or troctolites.

In their microscopic structure these rocks present many interesting features. From the highly crystalline gabbros there are two lines of descent to the vitreous tachylytes: one through the *ophitic* dolerites and basalts, and the magma-basalts with skeleton-crystals; and the other through the *granulitic* dolerites and basalts, and the magma-basalts with granular microliths. The former are shown to result from the cooling down of molten masses which were in a state of perfect internal equilibrium; while the latter were formed when the mass was subject to movement and internal strain.

It is shown that in the most deeply seated of these rocks (gabbros) the whole of the iron-oxides combine with silica; but, as we approach the surface, the quantity of these oxides separating as magnetite increases, until it attains its maximum in the tachylytes. In all the varieties the order of separation of the different minerals is shown not to depend solely on chemical causes, but to be influenced by the conditions under which the rocks have cooled down.

Although these rocks are not highly altered ones, yet they afford admirable opportunities of studying the incipient changes in their constituent minerals. The nature of these changes is discussed, and they are referred to the following causes:—(1) the corrosive action of the surrounding magma on the crystals; (2) the changes produced by solvents acting under pressure in the deep-seated masses (these have been already described under the name of "schillerization"); (3) the action of heated water and gas escaping at the surface; (4) the action of atmospheric agents on the rocks when exposed by denudation; and (5) the changes induced by pressure during the great movements to which rock-masses are subjected.

II.—Jan. 13, 1886.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.

The President said, It may not be known to all present this evening that during the past week we have lost a well-known member of forty years' standing. Prof. John Morris died last Thursday, and to-day some of us have stood by his grave in Kensal Green Cemetery. The Society has lost its most learned member, and many of us have been deprived of a very dear friend.

1. "On some Fish-remains from the Tertiary Strata of New Zealand." By James W. Davis, Esq., F.G.S.

A number of fossil fish-remains from Tertiary beds in New Zealand have been forwarded to the author by Captain F. W. Hutton, and were described in the present paper. The forms of which descriptions were given are two new species of *Lamna*, *Carcharodon angustidens*, Agassiz, and a new *Carcharodon*, one new species of *Notidanus*, one of *Myliobatis*, and one referred to *Sparnodus*. All the above are founded on teeth. A vertebra of *Lamna* and a fish-spine were also described, and the collection contained a specimen regarded by the author as a fragment of a Reptilian tooth.

2. "On a recent Section through Walton Common, exposing the London Clay, Bagshot Beds, and Plateau-gravel." By W. H. Hudleston, Esq., F.R.S., F.G.S.

During the past autumn the widening of the line between Walton and Weybridge stations has afforded a very interesting section in the above beds, showing their relations to each other with considerable clearness. Walton Station is 68 feet above O.D., and immediately to the westward the section described in the paper commences, the surface of the country gradually rising to a height of about 120 feet in the plateau which separates the drainage of the Mole from the drainage of the Wey. This plateau is connected on the south by a slope with the higher and far narrower plateau of St. George's Hill, having an elevation of 245 feet.

For convenience of reference the portion of the section more particularly described, and which has a length of 1070 yards, is divided into four blocks:—

Block A extends from Walton Station to where the unaltered London Clay is seen—313 yards.

Block B extends from this to the point where the Bagshot beds are first seen *in situ*—345 yards.

Block C extends from the above to the point where the Bagshots are first cut through to the level of the line, and the hollow filled up with Plateau-gravel—165 yards.

Block D exhibits the relations of the Bagshots to the Plateau-gravel, where the latter is most fully developed—247 yards.

Details of Block A.—This portion of the section rises from zero to 12 or 14 feet; the first bed which becomes visible is the "Top Sand," and on advancing further westward portions of a peculiar mixture of gravel and lumps of brown clay form the sides and floor of the cutting. This is evidently a disturbed series, and has peculiar relations with a mass of yellow sand, mainly false-bedded, which is 70 yards long, and from 12 to 14 feet high at the west end. The London Clay *in situ* rises very suddenly beyond this. Reasons were given for supposing this sand to be a superficial deposit against a steeply eroded surface of London Clay.

Details of Block B.—The London Clay of this block has yielded no fossils, nor are any Septaria visible. The bedding is difficult to distinguish, but recent weathering has made it more plain. This seems to establish a very slight dip towards the west. The surface of the London Clay is undulating, and it is overlain by from 6 to 7 feet of Plateau-gravel.

Details of Block C.—In this block, where the cutting has a depth of about 24 feet throughout, occurs the junction of the Lower Bagshots with the London Clay, and this is apparently an unconformable one. Both the lithology and the stratigraphy favour this view. Nothing in the nature of a lithological passage exists. The lowest bed of the Bagshots here is remarkably clear sand full of false-bedding, and is succeeded by an argillaceous series, also somewhat sandy. It was suggested that this latter might be the equivalent of the "Ramsdell Clay."

Details of Block D.—Here the Plateau-gravel attains its maximum thickness, since the Bagshots are cut through to the level of the line in three places—depth of cutting from 24 to 27 feet,—thus affording a fine opportunity for the study of this peculiar deposit. Three horizons were roughly made out, or, rather, three varieties occurring one above the other. Beyond the limits of the section there is more distinct evidence of at least two groups in these Plateau-gravels. No materials from the northern drifts are found.

Other sections in the superficial beds were noticed, and more especially one about the 180-feet line on the north slope of St. George's Hill, where the contortions are of considerable interest.

PROF. JOHN MORRIS, M.A. CANTAB., F.G.S., ETC.

BORN FEBRUARY 19TH, 1810; DIED JANUARY 7TH, 1886.

[For more than twenty years one of the Editors of this MAGAZINE.]

The new year has gathered into its earliest garner another ripened human intellect, whose influence and usefulness in the Geological world for nearly 50 years have done much to promote in others a love for our science to which that life was devoted.

Professor John Morris was born in the very dawn of accurate Geological thought in this country.

Eight years before his birth, in the spring of 1802, Playfair had published his celebrated "Illustrations of the Huttonian Theory." In 1807, a handful of scientific men met together and founded the Geological Society of London; and from 1799 to 1815 William Smith (better known as "the Father of English Geology") was plodding over England, with quiet unobtrusive labour, preparing, unaided, his work, entitled "Strata Identified by Means of their Organized Fossils," and his great "Map of the Strata of England and Wales."

In June, 1812, James Sowerby commenced to publish (in about bi-monthly parts of 5 plates each) his "Mineral Conchology of Great Britain."

Such was the condition of the literature of our science in England early in this century. There were no text-books for young geologists in those days, and the science of Geology was no easy path to pursue; yet John Morris had already taken up the study of rocks, minerals, and fossils, and commenced to collect materials for his "Catalogue of British Fossils," before the first edition of Lyell's "Elements" had been printed, and as early as the first appearance of his "Principles of Geology," a little book of one volume 8vo., which saw the light in January, 1830, whilst Morris, then twenty years of age, was engaged in business in Kensington as a Pharmaceutical Chemist.

The modest precursor to Morris's Catalogue was printed at Norwich, and designated "A Synoptical Table of British Organic Remains, in which all the edited British Fossils are systematically and stratigraphically arranged in accordance with the views of the geologists of the present day, and a reference given to their localities, strata, and engraved figures, by Samuel Woodward." This little book of fifty pages, which appeared in 1830, gave all that was known at that date concerning our British Fossils.

Morris published the first Edition of his Catalogue in 1845, but he had issued preliminary notes, section by section, in the "Magazine of Natural History" from 1839 to that date.

The second edition appeared in 1854; but though constantly urged by his friends to do so, and incited by the awards of the Geological Society, he never achieved a third edition.

From 1854 to 1877 Prof. Morris held the Chair of Geology in University College, and during that period he delivered no fewer than 1100 lectures to his class, besides directing field-excursions, and giving demonstrations in the Museum.

Of the details of his life and work and the well-merited honours that have been conferred upon him, a full account will be found in the GEOLOGICAL MAGAZINE, Decade II. Vol. V. November 1878, pp. 481–487, accompanied by a portrait.

Like all men of great mind, Prof. Morris had his peculiar traits of character; but he will be remembered by one thing, more than any other, namely, his extreme readiness to impart scientific information to those around him out of the vast (one might almost say *inexhaustible*) stores of knowledge which he had for years accumulated in his retentive mind, and yet could retail again most accurately when needed, and even recall the very place in the work from whence he had culled it.

Professor Morris was essentially a 'young-hearted' man with his friends, and especially so when out with his class, or with the Members of the Geologists' Association. Indeed, one has to compare events and dates in order to show that he was in reality a survivor in our time from the prehistoric age of geology. Morris was in fact the contemporary of Mantell, Buckland, Fitton, Searles V. Wood, Bowerbank, Scrope, Owen, Murchison, and Lyell; and of his earlier personal friends amongst the great geologists—alas! now few indeed in number —only Prof. Prestwich, F.R.S., of Oxford, remains.

It is not without interest to record that almost the last piece of work in which he engaged was to arrange, compare, and verify the original specimens of the "William Smith Collection," preserved in the Geological Department of the British Museum, the first collection formed with a view to prove that strata could be identified by their fossil contents.

Ill-health has prevented Prof. Morris for the past two years from attending scientific meetings or visiting his friends, as in days of yore; but up to the last he was cheered by nothing so much as a visit from a geological friend and a chat about some new geological book. And whenever his health permitted, he amused himself by continuing the preparation and revision of the lists of fossils for the third edition of his Catalogue.

He died on the 7th January from heart-disease, and was interred on the 13th at Kensal Green Cemetery, where many of his fellow-geologists assembled to do honour to so veteran an associate.

It will gratify the admirers of PROFESSOR MORRIS to learn that it is the wish of his friends and family to raise a suitable and lasting Monument to his memory, and that this memorial shall take the form of a THIRD EDITION OF MORRIS'S CATALOGUE OF BRITISH FOSSILS.—H. W.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. III.—MARCH, 1886.

ORIGINAL ARTICLES.

I.—On the Permanence of Continents and Ocean-Basins, with Special Reference to the Formation and Development of the North American Continent.

By Prof. Joseph Le Conte.

UNDER the influence, perhaps, of the prevailing idea of evolution in all things, the conviction has been growing in the minds of geologists in recent times that the larger features of the earth's surface have grown from the earliest times, and therefore that the places of the continents and ocean-basins have been substantially permanent. Prof. Dana is largely the originator and expounder of this view, and he has applied it with great skill to the American continent. But while I believe the view is substantially true, I cannot but think that it may be, and has been, pushed too far. It is true indeed that the opponents of the view have attributed to its advocates a strictness in the use of the term 'permanent' which they have never urged. It is true that by permanence is meant only permanence of *place*, not of outline, and that substantial permanence is not inconsistent with very large changes by oscillation, especially at the end of the great Eras. But, making every allowance for such latitude of meaning, there has been, undoubtedly, some confusion of thought and looseness of statement on this subject. We give a few examples.

Prof. Dana in his admirable manual, p. 149, gives a figure (fig. 206), which he calls "Archæan map of N. America." This is really a map of *Areas of exposed Archæan rocks*, and for such it is doubtless intended. It cannot, of course, be a map of the land of *Archæan* times (since Archæan rocks were formed on sea-bottom), but is approximately a map of land of early *Silurian* times. But being called an Archæan map of the continent, and being found in the chapter on Archæan times, the inattentive reader is led to infer that it represents land of that time; more especially as the rest of the present continent is spoken of and represented as submerged, and therefore by implication this part as, then, land. And as Prof. Dana afterwards treats these areas as the nucleus from which the continent was developed, he seems to begin this development from the *land of Archæan times*. I am quite sure that many have been misled by this figure and the accompanying statements.

Again, Prof. Chamberlin in his excellent "Geology of Wisconsin," vol. i. p. 62, gives a map somewhat similar to Dana's, which he calls a "Map of Laurentian land." It is, of course, again a map of Laurentian rocks, and therefore not of land of Laurentian times. But being evidently intended as a map of land of some time, and being given in the chapter on Pre-Laurentian history, the inference is unavoidable that it is intended to represent the land at the *beginning of the Laurentian* (Archæan) *time.* It is hardly necessary to say it is, again, approximately a map of earliest Palæozoic (Primordial) times. Thus it has come to pass that many, without reflection, have held that the development of the American continent may be traced from a nucleus existing in Archæan times. But of this there is in fact not the slightest evidence.

On the other hand, Prof. Hull has recently published a very interesting and suggestive paper "On the Geological Age of the North Atlantic Ocean,"[1] in which he tries to show that the places of the present continents were not declared *until the Mesozoic.* If this be so, then indeed the doctrine of the permanence of continents must be given up entirely; for the Mesozoic and Cainozoic together form but a small part of the entire history of the earth.

I believe that the truth lies between these extreme views. I believe that the place of the American continent was established and its nucleus formed *at the beginning of the Primordial time*; and that thus, in regard to the development of earth features, no less than of earth faunas, the name Primordial is peculiarly appropriate. This, I think, is the real view of Dana. I wish now to give as clearly and as briefly as possible what seem to me the main steps in the history of the American continent from the earliest times.

1. Of all rocks the Archæan are by far the most widely diffused on the American continent. although of course largely covered by later deposits. Not only do they form the surface rocks over large areas, but they seem everywhere to underlie other rocks; for wherever these latter have been pierced by wells or cut through by cañons, we find the Archæan beneath. It is hardly too much to say that they form the foundation rocks of the whole continent. If so, then, of course, in *Archæan times the American Continent was all sea-bottom.* Where was the land at that time? We know not for certain; but the subsequent development of the continent southward and westward suggests that its place was to the north-eastward. This view is farther strengthened by the fact that the development of the European continent south-westward would point to the north-westward as the place of the earliest land. Prof. Hull therefore, with much show of reason, assigns the North Atlantic as the place of the Archæan continent. The land from which such enormous masses of sediments were derived must have been indeed of continental proportions, and must have existed during immense periods of time, perhaps equal to all subsequent times put together. Its débris carried into south-eastward and south-westward seas formed the Archæan rocks of Europe and America.

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2. At the end of the Archæan, America (and probably Europe also) *became largely land.* This is a point of very great importance,

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[1] Trans. Roy. Dub. Soc., 1885, vol. iii. p. 305.

but not generally recognized. The evidence of this fact is found in the eroded condition, universal so far as known, of the Archæan rocks underlying all other rocks, even the lowest primordial. No one has ever seen conformable relation between the Archæan and any other later rocks. Not only is this unconformity found all about the border of the Canadian Archæan area and the Appalachian area and about all the smaller areas in the most widely separated parts of the continent, but the grand Cañon of Colorado cuts through the whole stratified series and into the Archæan exposing the line of contact, and we find the same unconformity; the St. Louis Artesian pierces the whole Palæozoic, and again from the sudden change in the character and condition of the rocks from unmodified into metamorphic, we must conclude unconformity. But unconformity means *eroded land surface.* Therefore we must conclude that well-nigh the whole continent was land at the end of the Archæan. It is almost certain therefore that at the end of the Archæan, there was a veritable exchange of sea and land, and that the North Atlantic Archæan continent became sea at that time. If so, the strata which were then formed, and of which the eroded surface of Archæan rocks is the sign and measure, are now beneath the sea, and therefore irrecoverably lost. This period between the Archæan and the Primordial I have elsewhere[1] called the "Lost Interval," because we have no record of it in the stratified rocks.[2] Judging by the amount of erosion of Archæan rocks, and also by the prodigious advance in the progress of life when the record commences again in the Primordial, this lost interval must have been a period of immense duration. There are in the history of the earth many other intervals, partially or locally lost, represented by local unconformities, the most important of which occurred at the end of the Palæozoic; but none of these are to be compared with that which occurred at the end of the Archæan.

3. The Palæozoic commenced with another large crust-movement, but not a complete interchange of sea and land as before. The American continent was again largely, but not completely submerged. It went down until only the now-known Archæan areas, together with an eastern area of unknown size now covered by the sea, were left. The continent then consisted of a large V-shaped land-mass corresponding to the well-known Canadian Archæan area, a large eastern land-mass, including the Appalachian Archæan area, but extending eastward at least as far as the submerged continental border, and a large mass in the Rocky Mountains, and especially in the Basin region, while a great interior continental sea occupied the position of the drainage basin of the Mississippi river. The so-called map of Archæan land of Dana and Chamberlin would represent approximately the condition of things at this time, if the eastern border-land were extended as far as the submerged continental

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[1] Am. Journ. Science, 1877, vol. xiv. p. 101. Le Conte's Elem. of Geol. p. 291.

[2] Some intermediate rocks have been found, *e.g.* the Kewenawan series, but the gap is still immense.

border.[1] *This*, the Primordial continent, *was the nucleus*, from which, by gradual growth, as so well shown by Dana, the American continent was formed. This growth was somewhat regular during the Palæozoic, but with another large oscillation at its end. The American continent existed, indeed, before, not however during the Archæan, as many seem to think, but during the "lost interval"; but it was almost destroyed at the beginning of the Palæozoic, to recommence its development with the nucleus already described. Thenceforward the plan thus outlined was apparently never lost.

4. During the Palæozoic the growth of the continent was comparatively regular, but at its end coincidently and correlatively with the formation of the Appalachian Range, the eastern land-mass was greatly diminished by submergence, and the eastern coast-line advanced westward far beyond its present position, especially in the southern part, probably as far as the well-known position of the Tertiary coast-line. After this oscillation, the development was again more regular, and in its broader outlines is well known. The great interior Palæozoic sea was diminished and became the interior Cretaceous sea, and this later retreated southward, to become finally the present Gulf of Mexico. There were probably many other times of lesser oscillation. The last of these was in later Tertiary and early Quaternary, during which the continent in its northern part again extended to the submerged continental border, with probable connection with Europe in the North Atlantic region.

Prof. Hull, in his paper already referred to, makes the changes in the latter part of the Palæozoic and at its end much greater than I have supposed, in fact equivalent to another almost complete exchange of sea and land. According to him (see his map, fig. 3), during the Carboniferous the whole of the North Atlantic and the northern parts of North America and of Europe formed together an enormous continental mass, the oceanic part of which was again submerged at the end of this period, to nearly the present limits of the two continents. It is not impossible nor even improbable that during the later Palæozoic the American continent may have grown on its eastern margin; or even that at some time during the long Palæozoic era there may have been a connection far to the north between the two continents; but of the complete abolition of the Atlantic Ocean, as shown on his map, I confess I see no sufficient evidence. The great thickness of the Carboniferous strata would, it is true, require a large land-mass to the east; but there is no reason why the eastern land-mass, which sufficed to contribute the 30,000 feet of Silurian and Devonian sediments, should not have been sufficient to contribute the much smaller amount of sediments of the Carboniferous period.

To re-capitulate briefly: 1. During the Archæan the American continent probably did not exist at all. 2. The first evidence we find of its existence is during the "Lost Interval." It was then a large land-mass of unknown size and shape, but evidently of continental proportions. 3. At the beginning of the Palæozoic this continental mass was nearly lost by submergence; all that remained being the well-known Archæan areas, with a large extension on the eastern margin of the present continent. The masses formed the nucleus ^se from which grew the present continent, with more regularity than before, but with some very large oscillations, the greatest of which was at the end of the Palæozoic, and the last of which was at the end of the Tertiary and beginning of the Quaternary.

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[1] The Silurian continent has been thus extended by Prof. Hull in his map, fig. 2; but why he has carried the northern part of the continental border westward so as to cut through Labrador, I cannot imagine. The whole of Labrador was surely land in Primordial times.

Berkeley, California, *January 14th*, 1886.

II.—Note on the Geological Relations of Rocks from Assouan and its Neighbourhood.

By Sir J. William Dawson, C.M.G., LL.D., F.R.S.

Dr. BONNEY having been so kind as to examine microscopically and describe a collection of crystalline rocks which I made in the vicinity of Assouan on the Nile, I have prepared the following notice of the geological conditions, to accompany his descriptions, referring, however, to the notes on the locality given in my paper in the Geological Magazine for Oct. 1884. Reference may also be made to the paper of Lieut. Newbold in the Journal of the Geological Society, vol. iv., and to that of Mr. Hawkshaw in the same journal, vol. xxiii. Lartet has given in his Geology of Palestine a summary of the observations of Russegger, Rivière and Figari Bey on the crystalline rocks of the Nile, and the allied rocks of the Sinaitic Peninsula have been described by him, by Bauerman[1] and by Holland,[2] and more recently by Hull.[3] All these authors have given, more or less distinctly, a series of gneisses and micaceous and hornblendic schists associated with intrusive granites and diorites as the oldest rocks of these districts, and succeeding these in geological age, certain slates and associated rocks, with porphyry and basanite in beds and veins.

The best section which I had an opportunity to examine of the older series was near the town of Assouan, in a railway cutting crossing the ridge between the river and the valley lying to the east of the town, and which exposed the beds in a perfectly fresh and unweathered state for about a quarter of a mile, beyond which they were more or less imperfectly seen for about 800 yards, until they were covered by the lower beds of the Nubian Sandstone unconformably superimposed on them.

I have given a section of the beds exposed in this cutting in the paper above cited. They are nearly vertical with a strike N. 10° E. As seen in the cutting, about four-fifths (Series *A* in Note) of the thickness exposed consisted of schists with black mica and black hornblende, the remainder being orthoclase gneiss regularly stratified and numerous dykes of reddish hornblendic granite (Series *B*. in Note). Further to the south the same rocks are seen to be traversed by great dykes of diorite, and the mass or dyke of granite which has been the most extensively quarried is situated to the north along the course of the same ridge. Some of the crumbling schists seen in the valley behind the town may have been calcareous, and may be associated with limestone now concealed, but no limestone was observed, though the character of the beds in comparison with those I have elsewhere seen might lead to the expectation of its occurrence in the vicinity.

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[1] Quart. Journ. Geol. Soc. vol. xxv. [2] Ord. Survey Sinai. [3] Mount Seir.

The Nubian sandstone, where it rests on these rocks, has, in its base, layers of conglomerate and of a calcareo-argillaceous indurated marl, but holds no fossils. It may be of Cretaceous age, but I should infer, from the character of the fossil wood (*Araucarioxylon Ægyptiacum*)[1] found in it elsewhere, and described by Schenk in Zittel's work on the Geology of the Nubian desert, that its lower beds at least may be Permian or Carboniferous.

The lithological aspect of the beds seen in the cutting at Assouan is that of the Middle or Grenville series of the Laurentian in Canada; indeed I find on comparison that the greater part of the rocks are not distinguishable in hand specimens from those occurring in this series on the Ottawa River.

In the Island of Biggeh, above the cataract, and on the higher parts of the mainland in its vicinity, there appears another formation (Series *C* in Note), very different in its mineral character, which, though older than the Nubian sandstone, I believe to rest unconformably on the older Assouan Series. In Biggeh the latter is seen in the lower part of the island in a vertical attitude and with strike N. 10° W. Strikes ranging from about N. 10° W. to N. 10° E. appear to prevail in this series, in the vicinity of the cataract, though in one place east of Assouan it was observed to be N. 70° E. Rising above the lower series, and apparently resting upon it unconformably, is a second series of beds nearly horizontal, and about 100 feet in thickness. They are composed as follows in ascending order:—

(1) Hard dark-coloured quartzose porphyry, with crystals of red orthoclase.

(2) Fine-grained granulite or granite, possibly a *remanie* rock.

(3) Black fine-grained laminated and in some places shaly rocks, referred by Professor Bonney to quartziferous kersantite.

(4) Granulite, like No. 2.

(5) Dark-coloured porphyry, with dark crystalline paste, and large crystals of opaque brick-red orthoclase.

The last is a very thick bed, and dividing along straight joints into huge cubical blocks, gives a castellated appearance to the hill and cliffs composed of this formation.

As seen from a distance, these rocks of the Second or Upper Assouan series appeared to be intrusive masses; but on nearer examination, they showed horizontal bedding, and at the base of the cliffs and in their ravines were seen to rest on the older series.

Assuming on the evidence of mineral character the Lower Assouan series to be Laurentian, and of Middle Laurentian age, the next rocks to be expected in ascending order would be the Upper Laurentian or Norian and the Huronian. To the former the second Biggeh series bears no resemblance, but there are known to be in the Arabian chain, and probably associated with the equivalents of the Assouan rocks, Norian rocks of the character of anorthosite gneiss, a rock which was used by the ancient Egyptians for statuary,[1] but is generally called diorite by antiquaries, though it differs very much from the true diorites of the country.

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[1] See W. Carruthers in Geol. Mag. 1870, Vol. VII. p. 306, Pl. XIV.

Dr. Schweinfurth has sent me from the districts of the Arabian chain north of Assouan, a rock similar to the more compact variety of the dark Biggeh rock, which he states forms ridges parallel to the main chain of crystalline rocks. Newbold refers to greenish and chocolate-coloured schists and quartzite, as bordering the older schists and granites, and Lartet notices talcose and chloritic slates with granulite in a similar relation, crowned by the celebrated green conglomerate and breccia of Kosseir and Gebel Doukhan. Further, Russegger connects the red porphyry and petrosilex porphyry with large felspar crystals of Gebel Doukhan with this second series, and Lartet has described the quartziferous porphyry of Mount Hor as lapping around the granite nucleus of that mountain.

It would thus appear that the old Laurentian gneisses and schists of Upper Egypt and its eastern mountain chain are succeeded by formations which may be held to represent the Norian and Huronian series at least, and I would regard the Biggeh formation or Second Assouan series as consisting mainly of bedded volcanic material representing some portion of the Huronian, a formation which would seem to have been more largely developed or to be better preserved in some parts of the Arabian chain to the north and east, where it is also overlain by slaty rocks, and by the green conglomerate which either constitute an Upper Huronian series, or may represent the Ammiké and Kewenian formations of America. There would seem in this district to be a great geological hiatus between these old rocks and the Nubian Sandstones.

III.—NOTE ON THE MICROSCOPIC STRUCTURE OF SOME ROCKS FROM THE NEIGHBOURHOOD OF ASSOUAN, COLLECTED BY SIR J. W. DAWSON.

By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S.

I HAVE not deemed it necessary to examine microscopically the whole of the collection made by Sir J. W. Dawson, but have selected a series of fairly representative specimens, sufficient, I think, to give a general idea of the principal varieties. For purposes of identification I leave the reference numbers borne by the specimens, though their sequence is accidental.

(*A.*) OLDER GNEISSIC SERIES, ASSOUAN.

(3.) A moderately fine-grained holocrystalline pink and white rock, speckled with black, of slightly gneissic aspect.

Microsc.—Quartz, felspar, orthoclase with some microcline and plagioclase, biotite, occasionally showing signs of alteration to the usual green mineral, a little apatite, and a small yellowish mineral probably sphene. The rather irregular outline of the felspars and the granular aggregation of the quartz resembles in some respects the structure of a gneiss rather than a granite, but it is very probable that this structure is the result of some pressure and crushing after the consolidation of the rock, of which the hand specimen gives indication: in all other respects one would not hesitate to call it a granite.

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[1] The fine statue of Kaphra or Cephren in the Boulak Museum is of this stone.

(4.) A rather fine-grained holocrystalline rock, speckled pinkish and dark coloured.

Microsc.—Quartz, felspar (orthoclase, microcline, and plagioclase), with a considerable amount of brown mica, a little apatite and epidote or sphene, with a very little iron peroxide. It is extremely difficult to say whether this be a gneiss or a granite crystallizing after the vein granite type (granulite of Fouqué and Lévy), modified slightly by subsequent pressure. After all, perhaps, some of the very coarse ancient gneisses may be only crushed and recemented granites.

(5.) A rather fine-grained holocrystalline rock, speckled pinkish and dull green; general tint inclining to dark.

Microsc.—The remarks on (4) will apply here, except that there is rather more biotite and apatite. The structure also is more gneissic, but it is very doubtful from indications given by the slide whether we can trust this, and whether the rock may not originally have been a granite.

(7.) A dark crystalline hornblendic rock, with a slightly fissile structure.

Microsc.—Holocrystalline; hornblende and felspar (chiefly plagioclase), a little epidote (probably) and magnetite, a flake or two of biotite, and a very little apatite. Very difficult to decide upon the origin of this rock. I incline to think it igneous, and a diorite.

(8.) A rather dark grey and pink, somewhat finely crystalline rock, with fairly distinct foliation.

Microsc.—Quartz, felspar,—orthoclase, a little microcline, plagioclase (? albite),—biotite, with a little iron peroxide, and a very little apatite. The structure much resembles that of one of the old Laurentian gneisses, which is also in accordance with the macroscopic aspect of the rock.

(11.) A gneiss distinctly streaked with pinkish felspathic and dark hornblendic or micaceous bands; the former, with occasional rounded felspars, have an aspect suggestive of much crushing. This appearance is fully confirmed by microscopic examination. The rock has evidently been once either a hornblendic granite or a granitoid gneiss, and its present structure is due to great crushing, so that in parts it is like an ordinary fragmental arkose. The dark mineral appears to be chiefly hornblende, though much biotite is also present; its crystalline grains are mostly small. Orthoclase, microcline and plagioclase were probably among the felspars of the original rock. There is some apatite, also sphene (?), ilmenite (?), and a crystal of a dark brown mineral unknown to me.

(12.) A very dark distinctly foliated schist, composed chiefly of mica and a decomposed (?) felspathic mineral; some of the mica has a brassy lustre. The attempt to obtain a slice of this rock has been a failure, as it is so friable.

(13.) A hard quartzose schist, with not much mica, and little signs of foliation.

Microsc.—The principal constituents are quartz, felspars of more than one species, and brown mica. The rock appears to have been squeezed, but not crushed. It has the aspect of a true gneiss, one of the fine-grained kinds that rather resemble quartzites.

(14.) Rather like (12), but with a felspathic vein.

Microsc.—Dominant minerals, plagioclase, biotite, hornblende, some quartz, but variable in distribution. Parts of the slide might thus be called hornblendic gneiss, the rest rather hornblendic mica-schist. The rock certainly must now be called one of the above names, but there are peculiarities in its structure which prevent me from making any confident statement as to its origin.

(15.) A rather 'slaty' fine-grained gneiss, related to (13), but more fissile.

Microsc.—It has a general similarity to (13), but contains more mica. Also it has yielded more to pressure.

I may add that among the specimens from this series are several rather fine-grained dark mica-schists or very micaceous gneisses, varying between (12) and (15), which are so obviously representatives of the "metamorphic" group of rocks, that I have thought it needless to examine them under the microscope. They have a general resemblance to schists not unfrequent in the upper parts of the Hebridean series of Scotland, and may be compared with some of those which occur (for example) in the neighbourhood of Gairloch (Ross).

(*B.*) Rocks Intrusive (Dykes, etc.) in Series A.

(1.) A holocrystalline rock, mottled dark green (almost black) and light yellowish, with porphyritic felspar crystals of latter colour, sometimes about one inch long.

Microsc.—Consists of quartz, felspar—orthoclase, microcline, plagioclase (albite ?)—hornblende, biotite; with a little magnetite, a good deal of apatite in well-defined hexagonal prisms, and a little of a granular yellowish mineral, probably sphene. Thus the rock is a hornblendic-granite; it is not very rich in quartz.

(2.) Coarsely crystalline rock, with large pinkish-red felspar crystals, quartz, some whitish felspar and black mica. One of the granites commonly used in Egyptian monuments, and, as is often the case with these, it has a gneissoid aspect.

Microsc.—Holocrystalline; quartz felspar, chiefly microcline, with some plagioclase, brown mica, with a little hornblende, a little magnetite, some apatite, and a yellowish mineral; sphene, or perhaps epidote. The irregular outline of the felspar and the aggregated granules of quartz resemble a gneiss, but this may be due to subsequent crushing.

(6.) A holocrystalline rock, moderately coarse, speckled with light greyish colour and black (mica).

Microsc.—Quartz, felspar (orthoclase, microcline, and plagioclase), a good deal of biotite and hornblende, rather rich in apatite, some magnetite, some sphene (one crystal rather large), also several long colourless needles, ? sillimanite; a hornblendic granite, rather poor in quartz.

(*C.*) UPPER SERIES AT BIGGEH (ASSOUAN).

(9.) A dark rather compact rock, with but slight indication of a schistose structure.

Microsc.—Holocrystalline; quartz, felspar (apparently both orthoclase and plagioclase, but not very well characterized), biotite and hornblende, with a little magnetite, apatite, and sphene. It resembles a hornblende schist, but slightly foliated, rather than an igneous rock.

(10.) A dark rather compact massive rock with rectangular jointing.

Microsc.—Holocrystalline, but not coarse, composed of biotite, rather dark-coloured, but partly altered into a greenish mineral, and hornblende with some quartz, and a fair amount of felspar, which seems commonly to be plagioclase; a little apatite, magnetite or hematite, and sphene. The mica (with perhaps the hornblende) appears to have been the first mineral to crystallize. The rock appears to me to belong to the mica-trap group, and to be a quartziferous kersantite.

(16.) A dark rather fissile rock, looking more like a bad slate than a true schist.

Microsc.—At first glance it seems very fragmental, but on careful examination I feel convinced that we are dealing with a crushed crystalline rock, which has consisted chiefly of felspar and hornblende. There is a fair amount of apatite, and some of the hexagonal crystals appear to have escaped the crushing, or have been subsequently formed. I notice a few flakes of brown mica and there are indications of iron oxides. Thus it is now a schistose rock, not of a highly metamorphic aspect, but has been made out of a diorite or a hornblende schist.

The "coarse dark-coloured porphyritic rock" from this series (No. 1 of Sir J. W. Dawson's series at page 440 of the volume of this MAGAZINE for 1884), if I have rightly identified the specimen, is holocrystalline and it appears to me to be a true granite. I may add in regard to this "upper series" that, if I am right in my interpretation of (16), the specimens do not suggest to me the necessary existence of a wide gap between them and those of the lower series; that some appear to me igneous rocks, and that the others, if not igneous, belong to a highly crystalline group of rocks.

REMARKS.

I have had to speak with some hesitation as to the nature of certain of the above described rocks. This is always needful in dealing with any series of very old rocks, especially when one has not had the opportunity of examining them in the field, because we are not yet sure of the significance of certain structures and their relation to the origin of the rock. But while I cannot positively assert that some of the rocks included in series *A* (Older Gneissic Group) may not be rocks of igneous origin, to which a schistose structure has been imparted by subsequent pressure, I think it highly probable that they assumed their present character at a very remote period in the world's history, and may remark that this difficulty is one which frequently confronts us in examining the older Archæan series. But, while admitting this uncertainty, I observe in some of the specimens the structures which I have been accustomed to note as characteristic of the older gneisses, and was independently struck with the resemblance which some of them presented to specimens collected by myself in Canada and in N.W. Scotland, especially in the case of (13), which is very like to a "quartzose gneiss," high in the Grenville series, shown to me by Sir W. Dawson in 1884, near Papineauville Station on the Ottawa river. Thus the series as a whole may safely be regarded as petrologically "homotaxial" with the middle part of the Canadian Laurentians.

IV.—ON THE OCCURRENCE OF TWO SPECIES OF MADREPORARIA IN THE UPPER LIAS OF GLOUCESTERSHIRE.

By ROBERT F. TOMES, F.G.S.

THE few recorded Madreporaria of the Upper Lias possess considerable interest on account of the great generic as well as specific differences which exist between them and those from the Middle and Lower Lias, though it might seem probable that the discovery of a greater number of species would diminish that discrepancy. Such a conclusion has not, however, by any means been substantiated by further acquaintance with those from the Upper Lias of the district of which I am about to speak.

The late Mr. Charles Moore in his exhaustive paper, "On the Middle and Upper Lias of the South-West of England,"[1] gives sections of the Upper Lias exposed in quarries on the hills at Stanley and Dumbleton. Both these places are in the eastern part of Gloucestershire, and a reference to the paper above quoted will show that the sections there very closely resemble each other. The quarry on Stanley hill is now closed, but a waste heap yet remains, on the upper surface of which are numerous little hillocks of weathered clay and shale. They represent the barrow loads of clay from near the bottom of the quarry, which have been wheeled out by quarrymen preparatory to lifting the Middle Lias Marlstone below. The influence of weather having first reduced these hillocks to a light blue or grey mud, and afterwards dried them into the consistency of ashes, a considerable number of small lenticular corals were found on their surface, and many were collected during the summer of 1885 by my friend Mr. T. J. Slatter, and myself. Belemnites occurred in great abundance, as well as small Ammonites (probably *Ammonites Hollandrei*), but although in near association with the corals, they were not found mixed together. In much nearer approximation were numerous small glittering crystals of pyrites, small Gasteropoda, fragments of Pentacrinites, and Acrosalenias.

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[1] Proceed. Somerset Arch. and Nat. Hist. Soc. vol. xiii.

With a view to determine, if possible, the precise stratigraphical position of the corals, I visited the Dumbleton hill quarry, only three miles distant, still in work, and satisfactorily determined their horizon.

The following is an accurately measured section, showing the beds at present exposed:—

	ft.	in.
1. Surface soil	4	0
2. Fish bed, fine grained and laminated stone, with Saurian remains, *Leptolepis concentricus*, and insects	1	0
3. Laminated blue shales	14	0
4. Layer of intermittent nodules of hard stone containing fucoids	0	3
5. Laminated blue shale, like No. 3	3	0
6. Whitish grey clay, hard and breaking up into angular lumps, and weathering into a soft light-coloured clay	0	9
7. Hard light blue shale, in the lower part of which are many Belemnites, and in the upper part numerous small cubes of pyrites, small Ammonites (*A. Hollandrei*) and Gasteropods	1	3
8. Friable shale, having the appearance of soft marlstone, brown or ferruginous in colour, and sometimes micaceous	1	0
9. Middle Lias Marlstone, very fossiliferous	3	0
	28	3

All the beds downwards, until we arrive at No. 6, are finely laminated, and it would be time wasted to seek for corals in them. However beds 6 and 7 are wholly different. The first of these, No. 6, is light-coloured and hard, breaking up with the hammer into more or less square or angular lumps. It appears to contain very few fossils. No. 7, like the one above it, is not laminated, but is bluer, softer, and much more fossiliferous. Near to the bottom of it are Belemnites in abundance, and it also contains a great many small specimens of *Ammonites Hollandrei*. Very near to, or at the top, are a great number of crystals of pyrites, similar to those at the Stanley hill quarry. These two beds weather down into a soapy and disagreeable mud, and this perhaps accounts for their having been wheeled well back on to the top of the waste heap out of the way, both at Stanley and Dumbleton. The corals are much less common at the latter than at the former place, only two specimens having been met with. Both were in close proximity to the layer of pyrites, and in the top part of bed No. 7, or in the division between that bed and No. 6. At Stanley hill, where the corals are plentiful, they were found either in association with the pyritic crystals, or in a lighter coloured mottled clay, such as would be caused by the weathering down and mixture of beds Nos. 6 and 7. The conclusion at which I arrived, after making examination, was, that they lie chiefly between the two above-mentioned beds, and that they denote a quiet period during the deposition of the transition beds from the Middle to the Upper Lias. This is also the position of the peculiar so-called *Montlivaltia* which occurs in the transition beds from the Middle to the Upper Lias at Adderbury and Chipping Warden, Oxfordshire, to which I gave the name of *Montlivaltia tuberculata.*

Bed No. 8 is, without doubt, the top of the Middle Lias, differing only from the Marlstone beneath in being less compact. As I have already stated, the late Mr. Moore gave sections of the Upper Lias exposed in the quarries on the hills at Stanley and Dumbleton, a reference to which will show that the two sections very closely resemble each other.

In the paper alluded to is also a detailed section of the Upper Lias at Ilminster, from which Mr. Moore obtained the corals figured by MM. Milne Edwards and Haime, under the names of *Thecocyathus Moorei*, and *Trochocyathus primus*. A comparison of the Ilminster section with the one here given of the Upper Lias at Dumbleton hill will show that the corals from the latter place and from Stanley hill occupy a very different place in the section to the species just mentioned; but they, as already observed, correspond stratigraphically with those from Adderbury and Chipping Warden, and one of the species, as I shall show, is the same.

Two species, representing two genera, were collected at Stanley hill, namely *Thecocyathus* and *Trochocyathus*.

THECOCYATHUS TUBERCULATUS, Tomes.

Montlivaltia? tuberculata, Tomes, Quart. Journ. Geol. Soc., vol. xxxiv. p. 192, 1878 (read 1877).

The greater number of the specimens collected at Stanley hill are referable to the species which I have erroneously, but with an expression of doubt, described as a *Montlivaltia*, under the name of *Montlivaltia? tuberculata*. Their state of preservation being very superior to that of the Oxfordshire specimens, from which I took my description, I am now enabled to amend it very considerably, and to place the species in another genus.

All the Stanley hill specimens are rather smaller than the ones from Adderbury or Chipping Warden. The general form of the corallum is similar in the specimens from all these localities, and the calice of those most satisfactorily preserved is superficial, and varies from a slight convexity to a slight concavity. There are three complete cycles of septa and a rudimentary fourth. Those of the first pass quite into the columella, and those of the second approach it very nearly. The septa of the third cycle are two-thirds the length of those of the second. Those of the first and second cycles have their outer half crenulated rather than tuberculated, while their inner half has strongly marked paliform tubercles, which are four in number on the primary septa, and three on the secondary ones. Sometimes there is a single paliform tubercle on the septa of the third cycle, but this does not seem to be a constant character, and its appearance is perhaps regulated by the age of the individual. In some specimens these tubercles are much more prominent than in others, but all in the same calice have an equal prominence and are equal in size. The columella has very little prominence; it is small, porous, and irregular, and the tubercles on its upper surface correspond with those on the septa from which, in the unworn calice, they are undistinguishable. The appearance presented by the most perfect examples is that of a central area filled with equal, round, and equally prominent tubercles; but when the calice is rubbed or worn down, these all disappear, and the simple septa are seen to pass quite up to the columella. The sides of all the septa have rather distant but well defined and prominent tubercles.

Compared with *Thecocyathus mactra*, the present species differs in its smaller size, its much more rugose epitheca, and in its pali, the margins of which are much more tubercular. The tubercles are undistinguishable from those of the columella, with which they appear to blend.

I may take this opportunity of observing that with access to a considerable collection of specimens of *Thecocyathus mactra*, and *Thecocyathus tintinnabulum*, as well as to a number of species of *Thecocyathus Moorei* from the Upper Lias of Ilminster, I am not only satisfied of the distinctness of the species from the Upper Lias of Gloucestershire and Oxfordshire from the others, but am fully prepared to follow M. de Fromentel in putting together as one species *Thecocyathus mactra* and *Thecocyathus tintinnabulum*.

I also avail myself of the present occasion to make a few remarks on the genus *Thecocyathus*. Amongst the most ancient of the *Turbinolidæ*, this genus might not unnaturally be expected to possess characters approximating it in a greater or less degree to the Lower Mesozoic *Astræidæ*, with which in time it is so nearly associated. None of the *Turbinolidæ* have to my knowlege been met with in the Lower or Middle Lias, but I may observe that although the *Montlivaltia radiata*, of Duncan, which occurs in the bottom of the Middle Lias, or perhaps at the junction of the Middle with the Lower Lias, has an abnormal and primitive number of primary septa, it nevertheless has a very thin epitheca scarcely obscuring the costæ, which is quite unlike that of any genus or species of older date.

Again, the sides of the septa of *Montlivaltia mucronata*, which is found associated with the last species, are ornamented with thickly crowded flattened tubercles, instead of the vertical ridges which characterize nearly all the Jurassic *Montlivaltiæ*. These peculiarities seem to indicate some affinity in both these species with more recent forms.

In *Thecocyathus tuberculatus* we have a very modified development of the inner ends of the principal septa, which is no doubt equivalent to the growth of pali, and the same sort of development takes place to a considerable though more limited extent in *Thecocyathus Moorei*, for I observe that when the calice is ground or worn down, the pali are with difficulty traceable. Some of the much worn specimens are undistinguishable from *Montlivaltiæ*, having columellæ formed by the fusion of the septa in the centre of the visceral cavity. The genus *Thecocyathus* must therefore, I think, be regarded as very sub-typical of the *Turbinolidæ*—the precursor, in fact, of the more typical genera.

Nearly allied to *Thecocyathus* is *Trochocyathus*, but unlike the former, which continued into the period of the Lower Oolite and no longer,[1] the latter lived on through the Secondary and into

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[1] I limit my remarks to such species of *Thecocyathus* as have been met with in this country, one of which has been obtained from the Inferior Oolite of Dorsetshire. M. de Fromentel describes four as occurring in the French Oolites.

Tertiary times. *Trochocyathus primus*, which has been found associated with *Thecocyathus Moorei* high up in the Upper Lias of Somerset, is a very doubtful form, and the same may be said of the still earlier species spoken of in the present paper. But in *Trochocyathus magnevillianus* we have proof of the occurrence of an unquestionable and more typical Turbinolian in the Inferior Oolite. Of its precise position there I am unable to speak, but have great reason for supposing that it is only a little removed from the Cephalopod bed of the Upper Lias.

TROCHOCYATHUS.

With the preceding species occurs another coral which I refer to the genus *Trochocyathus*. All the specimens, which, however are few in number, are small in size and broadly attached, and in this respect are more like examples of the genus *Paracyathus* than *Trochocyathus*. They are wholly destitute of epitheca, and their mural costæ are well defined and have transverse crenulations. The calice is ovoid, convex, and consists in all the specimens I have examined of a confused mass of tubercles, which are more distinct towards the centre than outwardly. Neither the cycles of the septa, nor the pali can be satisfactorily traced.

Height of the corallum, 1 line. Greatest diameter of the calice, 1½ line.

V.—ON A RECENT LEGAL DECISION, OF IMPORTANCE IN CONNECTION WITH WATER SUPPLY FROM WELLS.[1]

By W. WHITAKER, B.A., F.G.S., Assoc. Inst. C.E.

ABOUT, or nearly, forty years ago, two deep wells (with borings) were made at Brentford, which, passing through Gravel, London Clay, and the Lower London Tertiaries, reached the Chalk at a depth of about 315 feet, and were carried some way into the last.

One of these wells is at the Brewery on the southern side of the High Street, now known as the Royal Brewery, and it continued in use till its water became unfit for brewing-purposes, from the cause noted below. The other is 99 yards off, north-eastward, at some printing-works at the back of the houses on the other side of the street. This one was made for a Distillery which has long ceased to exist; the well too having been abandoned, at least for its original purpose of water-supply.

Unfortunately, however, some years ago (from 1874 to 1882) the Distillery well, as we may call it, was turned to a baser use, being made into a cess-pit, by turning into it the drainage of the privy belonging to the printing-works. This misuse has ceased for some three years; but not before a considerable deposit had been formed in the well.

The water of the Brewery well, once of good quality, having been found to have become gradually contaminated, the owner, Mr. M. Ballard, sought to discover the cause, and, the misuse of the

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[1] Read before the Congress of the Sanitary Institute of Great Britain, at Leicester, Sept. 25, 1885. Extracted from vol. vii. of the Transactions of that Institute.

Distillery well having come to his ears, he was led to attribute to that the falling off in quality of his own well-water, the use of which was at once discontinued.

This led to his bringing an action against the owner of the Distillery well, Mr. Tomlinson, for heavy damages, and, although the misuse of that well was then stopped, of course its effects on the water of the Brewery well did not cease, and were not likely to for some time. Having, in the course of the proceedings, been consulted on the Plaintiff's behalf, I may be allowed to call public attention to the importance of the question at issue.

That the two wells get their water from one common source, the Chalk (and perhaps, to some extent, from the overlying sands), is incontestable. When no pumping goes on at either, the water-level is the same at both, about 27 ft. down in the Brewery well, and 37 ft. in the other, the site of which is some 10 ft. higher.

Practical evidence, however, of the communication between the two was given by the Brewery well being pumped for 48 consecutive hours, whereby its water-level was lowered 78 ft. 9 in., and that of the Distillery well 14 ft. In order, moreover, to make assurance doubly sure, the lithium-test was applied at the suggestion of Dr. Frankland, and some of the lithium-chloride put into the Distillery Well was found to have been drawn to the Brewery well 48 hours afterwards.

The question, therefore, of communication between the two wells could not be disputed; it was clearly a fact, and the Defendant's case was based on purely legal points, which amounted practically to the statement that any man could do as he liked with his own well, a contention which was successful at the trial before Mr. Justice Pearson, in February, 1884.

The judge ruled that, as it had been decided in the well-known case of Chasemore *v.* Richards, no one had a right to underground water so far as *quantity* is concerned, or in other words that neither Plaintiff nor Defendant could be restrained from pumping each other's wells dry, or from carrying out works that might take away each other's supply, so also there was no right in *quality;* but that the Plaintiff, whilst having a perfect right to pump as much water as he liked, so as to draw away water from the Defendant's well, must take that water subject to everything that has occurred to it. If he did not pump up the water from his own well, he would not get the bad water from the neighbourhood of the Defendant's well. I must own that to my unlegal mind the idea of having a well without pumping water from it was somewhat amusing, and I was inclined to infer that if it had been a case of an overflowing well, from which the water was delivered by the natural force of gravity, instead of by the artificial force of a pump, the decision might have been different, though why I do not see.

In his decision the judge seems to have been somewhat influenced by the possibility that, if the law were otherwise, actions might ensue for like pollutions at great distances, instead of the trifle of 100 yards as in this case, and, in his judgment, he imagines a series of litigants spreading the grounds for such an action over a distance of 60 miles. Though to a lawyer this may seem an inconvenient prospect, I think that sanitarians may be inclined to look on it with no disfavour.

The result of such a judgment amounts of course to saying that no underground water-supply is safe from contamination, even if wilfully brought about. Should your neighbour have a well with a good supply, and you wish to spite him, or to spoil his business, all that is needful would be to put down a bore to the source of supply, and to pour some poison down it! This matter, I believe, was noticed by one of the Plaintiff's counsel. Perhaps, however, in in such a case, or in one where sewage containing typhoid, or choleraic, evacuations was knowingly poured into a well, so as to foul a neighbouring one, the offender might be convicted of manslaughter, in a criminal case, though (under Mr. Justice Pearson's judgment) he would get the best of a merely civil action! This would certainly be a somewhat anomalous state of things, even as regards English law!

So many towns, institutions, and manufactories now get their water-supply by wells in the Chalk, and in other great water-bearing beds, that the result of such a judgment passing unchallenged would have been most serious. It would possibly indeed have been a great check to enterprise in that direction, as water thus got, perhaps at great expense, might at any time be made worse than that got from streams which are more or less contaminated.

The Plaintiff, however, was advised to take the case to the Court of Appeal, and all folk interested in the getting of pure water should thank the Master of the Rolls, and the Lords Justices Cotton and Lindley, for unanimously over-ruling the judgment of the Court below, as they did in February, 1885.

The Master of the Rolls holds that "although nobody has any property in the common reservoir or source [of underground water], yet everybody has a right to appropriate it in its natural state, and no one of those who have a right to appropriate it has a right to contaminate that natural source so as to prevent his neighbour from having the full value of his right of appropriation;" and he goes on to say, in answer to an objection that the water is got by artificial means (pumping), that "however he [the Plaintiff] may appropriate the water from the common source, he has a right to have that common source uncontaminated by any act of any other person." With regard too, to the question of distance, his judgment is equally satisfactory; for he says that "the question does not depend upon the parties being what is called contiguous neighbours. If it can be shown in fact that the Defendant has . . . . fouled . . . the common source, it signifies not how far the Plaintiff is from him."

Lord Justice Cotton draws attention to the fact that the Defendant was not using the water from his well, but only putting filth down the well, which does not amount to using a natural right, and by so doing, he "interferes with the exercise by the Plaintiff of a natural right incident to the ownership of his own land."

Lord Justice Lindley remarks that the case "really involves the question whether a person who has a well on his own land is at liberty to poison the water which supplies that well and a large district round about it. The defendant says he has such a right. It is a startling proposition to say the least of it." He adds that "the right to foul water is not the same as the right to get it. . . . . *Prima facie* no man has a right to use his own land in such a way as to be a nuisance to his neighbour. . . . . If a man chooses to poison his own well, he must take care not to poison waters which other persons have a right to use as much as himself. . . . . The right of a man to get water from his well is to get the water as nature supplies it."

As a geologist, much interested in the question of water-supply from underground sources, it was with a feeling of great relief that I heard of the view of this case taken by the Court of Appeal, and I read the full report of the judgments (from which the above quotations have been made) with much pleasure. I am inclined to think, indeed, that Mr. Justice Pearson, albeit he seems to hold strongly to the opinion that this is a free country, may feel relieved rather than grieved at the reversal of his decision. Had it been upheld, there would clearly have been great need of a little law-making.

Although all sanitarians must be glad of the final decision in this case,—for it will not be carried to the House of Lords,—yet it seems unfortunate that the privilege of bringing up so important a matter for settlement should have fallen to individuals instead of to corporations or to companies, on whom the expense would have more fairly fallen. It may be but a poor consolation to both Plaintiff and Defendant, that their names will become famous, like those of Chasemore and Richards, from the case of Ballard *v.* Tomlinson being one that is likely to be quoted for many years, as giving a most important decision in the law of water-supply from wells.

Whilst it was decided, in the earlier case, that every owner has the right to draw underground water to an unlimited extent, the decision now noticed is to the effect that no owner has the right to pollute a source of water-supply common to his own and other wells. Whatever may be the fate of the former decision, it is to be hoped that the latter one will never be altered.

VI.—RECENT AND FOSSIL HIPPOPOTAMI.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S., etc.

(PLATE III.)

IN September last, I drew the attention of the readers of the GEOLOGICAL MAGAZINE (Decade III. Vol. II. pp. 412–425) to a singular group of vegetable-feeding aquatic animals, the SIRENIA, represented at the present day by two genera, *Manatus* and *Halicore*, and by at most six species, three or four of which are probably only varieties. A peculiarity of this group of animals is that whereas the two living genera are distributed in the subtropical regions East and West of

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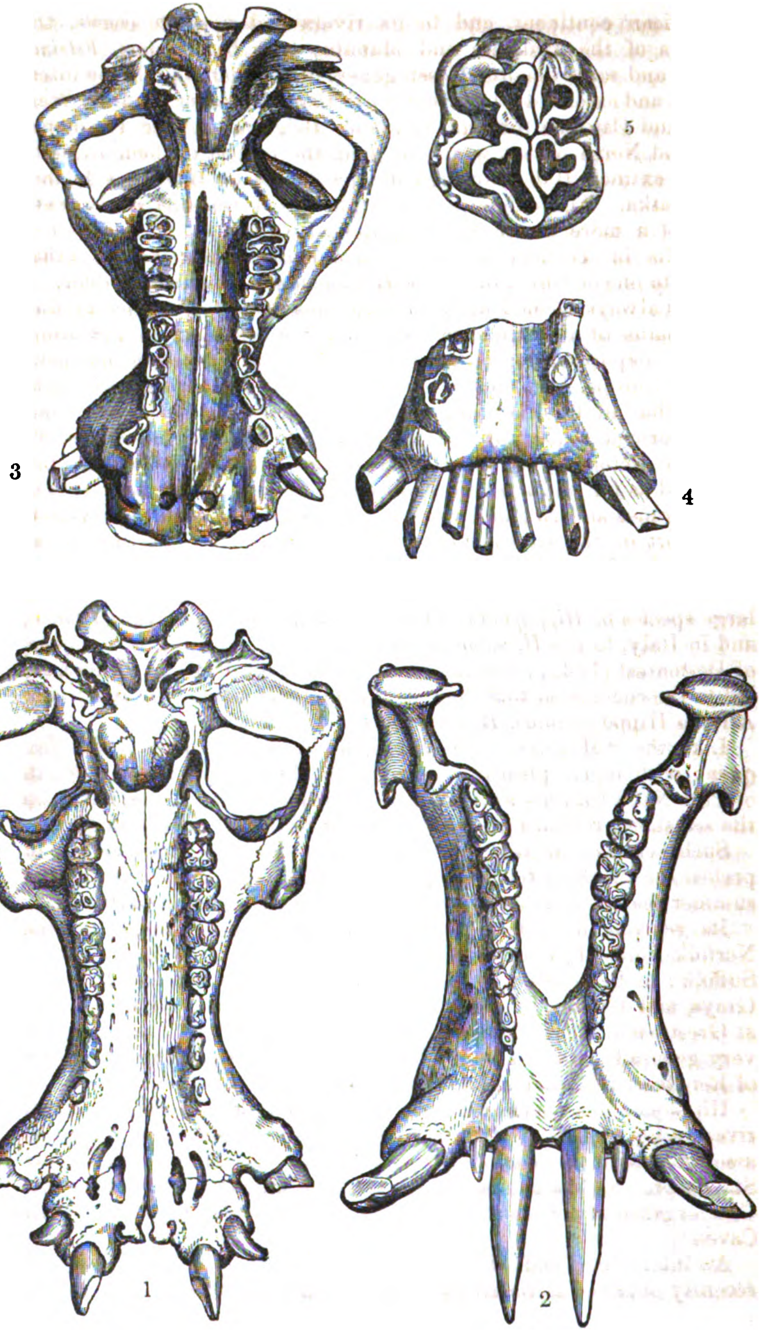

FIGS. 1, 2. *Hippopotamus amphibius*, Linn. (recent).
3—5. „ *sivalensis*, Falc. & Caut. (fossil).

the African continent, and to its rivers and opposite coasts, the ancestors of the Halicore and Manatee (the *Halitherium*, *Felsinotherium*, and some ten other fossil genera of Sirenians) probably intermingled and extended 30° further north than at present from the West Indies and Carolina through England, Belgium, France, Germany, Italy, and North Africa, whilst *Rhytina*, the largest of them all, only became extinct 100 years ago on the shores of Behring's Island, Kamtchatka. The evidence which the fossil remains of SIRENIA afford of a more northerly geographical extension of subtropical mammalia in Tertiary times, is abundantly confirmed by other genera, to one of which only, the *Hippopotamus*, I will here refer.

It has always seemed at first an anomalous circumstance to find the remains of the *Hippopotamus* and the Reindeer in the same Tertiary deposits, the latter belonging to the extreme northern lands of Europe, Asia, and North America, and the former to Central Africa; but in late Tertiary and early Prehistoric times, when our island formed a part of the mainland of Europe, the migratory herds of Reindeer not only reached this country in winter, but advanced as far south as into France and Spain; whilst the rivers of Italy, France and England were all the summer, if not the winter, the resort of the *Hippopotamus*, which has left its remains as far north as Leeds and Kirkdale in Yorkshire.

It was formerly customary to refer the numerous remains of the large species of *Hippopotamus* found fossil in this country, in France, and in Italy, to the *H. major*, of Owen (1843), or to the *H. antiquus*, of Desmarest (1822); but the researches of Prof. Boyd Dawkins have led to the conclusion that they all undoubtedly belong to the living African Hippopotamus, *H. amphibius* of Linnæus (1766).

Like the "Manatee," the *Hippopotami*, where undisturbed, frequent with equal pleasure the coast, as they do the rivers. North of Port Natal they are said not only to abound in the rivers, but upon the sea-shore, retreating to the sea when disturbed or attacked.

Such evidence as this enables us to understand the presence, in prehistoric times, of the *Hippopotamus* in Britain, at least during the summer season, even after its partial isolation from the continent.

Its remains have been found at Kirkstall, near Leeds; in the Norfolk Forest-Bed-series at Bacton, and Hasbro'; at Lavenham in Suffolk; at Barnwell, near Cambridge; at Chelmsford, Cold Higham, Grays, and Walton, in Essex; in the Valley of the Ouse at Bedford; at Greenwich, Kent; Peckham, Surrey; in Camden Town, in fact, very generally in the Thames Valley; often associated with remains of Reindeer, Rhinoceros, and Mammoth.

Hippopotamus-bones are less frequently found in caves, than in river-valley deposits; but in several their remains are recorded, associated with those of the Reindeer, namely:—Pont Newydd near St. Asaph, N. Wales; Kirkdale Cave, Yorkshire; Gower Caves, Glamorganshire; Cefn Cave; Settle Cave; and Durdham Down Caves.

An interesting and abundant find of Hippopotamus-remains was recently obtained at Barrington, near Cambridge (noticed by Mr. P.

Lake, GEOL. MAG. 1885, pp. 318–320. The geology of the locality and its superficial deposits have been very accurately described by the Rev. O. Fisher, M.A., F.G.S., see Quart Journ. Geol. Soc., 1879, vol. xxxv. pp. 670—677.)

Of the European localities three may be specially noticed as yielding remains of *Hippopotamus amphibius* in considerable numbers, namely, at Perrier and Puy de Dome in France, and in the Val d'Arno in Tuscany.

I have argued from the presence of remains of SIRENIA so widely distributed in the European Tertiaries a generally warmer climate, and I am glad to find that the late Dr. Falconer adopted the same view from the fact of the presence of remains of Hippopotami in so many English localities. This accomplished naturalist thus sums up his views:—"In speculating about the probable climatal conditions on the land in Europe during the Pliocene period, one of the fossil pachyderms has appeared to me capable of throwing more light than all the others, namely, *Hippopotamus major*. Two living species of this genus are known, the one *Hippopotamus amphibius*, and the other the small *Hippopotamus Liberiensis*. They are both found in the tropical or warmer parts of Africa. In their habits they are strictly aquatic, plunging into rivers during the day, and emerging at night to pasture along the river banks. They always hug the margins of the rivers or lakes, and are not known to make inland journeys away from them. When they migrate, they either float with the stream, or, if moving against it, they walk along the bed of the river, only leaving it for a short distance, when their course is interrupted by rapids, and replunging into the stream when the obstacles cease. Wherever they are found, they enjoy open water all the year round. Their unwieldy heavy form and short limbs are admirably adapted for their aquatic habits, but unfit them for journeying by land.

"There is no reason to believe that the huge European fossil species was in any respect less aquatic in its habits than its living congeners. Wherever its remains have been discovered in the greatest abundance and perfection, it has invariably been along the margins of rivers or great lakes, such as the Val d'Arno, where the bones of hundreds of individuals have been observed. It appears to have been spread over nearly the whole of the Pliocene area of England, since bones and teeth have been described from the valleys of the Severn, the Avon, and the Thames, Kirkdale Cave, Kent's Hole, and Durdham Down. The general argument, so ably discussed by Dr. Fleming, that we cannot predicate, in many cases, what the food and habits of extinct species of the same genus may have been, will not apply to the fossil *Hippopotamus major*, which must have lived in open water free from ice, if it lived the whole year round in England. That it was capable of migration by land more than the existing species we have no grounds for believing; and if it is argued that there may have been large rivers flowing from the south during the Pliocene period, along the course of which the Hippopotami could have migrated during winter, the argument might apply to the population of one or two river-valleys, but it would hardly extend to the Hippopotami spread over the broad area of England. In balancing these various considerations, it seems to me most probable that the *Hippopotamus major* was a permanent resident in the country during the Pliocene period. This would involve a comparatively warm temperature throughout the year as late as the deposition of the 'Grays Thurrock' beds, and the same would seem to be indicated by the presence of some southern freshwater shells,[1] which are now extinct in England."[2]

The living *Hippopotamus amphibius* appears to be met with on all the tributaries of the Nile, and was in earlier times abundant in Egypt also. It is still found on the Senegal and the Zambesi, and along the course of most of the rivers of the eastern coast, and along the coast itself, at many spots south of the equator to near Natal.

There is a second living species of Hippopotamus (*H. Liberiensis*), which is a much smaller animal than the common *Hippopotamus.* It rarely attains a weight exceeding four hundred pounds, or a quarter of a ton, as distinguished from the four tons weight attained by the male (Obaysch) which died at the Zoological Gardens in 1878, then twenty-nine years of age. One of the most important differences between the two consists in the fact that the Liberian Hippopotamus possesses only two incisors in the lower jaw.

The Siwalik Hills of India, whose older Pliocene deposits are so rich in the remains of Proboscidea and other Ungulata, have also yielded three species of *Hippopotami,* namely, *H. sivalensis,* F. and C.; *H. Iravaticus,* F. and C.; *H. namadicus,* F. and C., and one from the Narbadas, *H. palæindicus,* F. and C.

The first of these, *H. sivalensis,* is figured in our Plate (Plate III. Fig. 3–5); it is somewhat smaller than the existing species, *H. amphibius,* and has six incisor teeth in each jaw. This led Falconer to propose for those Indian forms with six incisors a new generic division, *Hexaprotodon,* the others being Tetraprotodont. *H. palæindicus* and *H. namadicus* evidently offer in the gradual diminution and squeezing out of one pair of their incisors, a distinct passage from the hexaprotodont to the tetraprodont type of the modern *H. amphibius.*

Prof. A. Gaudry has described a Pleistocene (?) species, *H. Hipponensis,* from Algeria. A small species of *Hippopotamus* has also been found fossil in Madagascar (Dawkins).

But perhaps the most interesting species met with in a fossil state are the *Hippopotamus Pentlandi,* H. von Meyer, and the *H. minutus* of de Blainville. The latter is from the Pleistocene Caves and fissures of the Island of Malta, where it has been found associated with the remains of the pigmy Elephant; the former was obtained from the Grotta di Maccagnone, near

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[1] *Cyrena fluminalis* is common in the Brickearths of the Thames Valley in association with *Rhinoceros Elephas* and *Hippopotamus.* Now it is found living in the Nile, and in India and China.

[2] "Falconer's Palæontological Memoirs," vol. ii. pp. 207–208.

Palermo, Sicily. So abundant were the remains of this species (*H. Pentlandi*) in the various caverns near Palermo, that, for many years, the bones were exported by shiploads to England and Marseilles, for the manufacture of lamp-black for sugar-refining. Two hundred tons were removed from one cave (San Ciro) in six months. Dr. Falconer writes that literally tens of thousands of two species of *Hippopotami* have been found fossil in Sicily alone. Mr. Lydekker considers there is a complete gradation in size from the largest fossil individuals of *H. amphibius* through *H. Pentlandi* to the smallest specimens of *H. minutus*. Prof. Boyd Dawkins evidently considers that *H. minutus* and *H. Pentlandi* are varieties of the same, and that they extend from Malta to Sicily, and thence to Crete and the Morea. He adds, "It is closely allied to the Liberian species, although it is pretty certain that it differed from it in the form of its molar teeth." The Hippopotamus possessed the following series of teeth, viz.:—

$$\text{incisors } \frac{2 \quad 2^{*}}{2 \quad 2} \quad \text{canines } \frac{1 \quad 1}{1 \quad 1} \quad \text{molars } \frac{7 \quad 7^{\dagger}}{7 \quad 7} = 40.$$

The molar teeth were of the bunodont type, their crowns being tuberculated (as in the Pigs, Mastodon and Manatee), and wearing down with use, so as to produce the characteristic double trefoil pattern (see Plate III. Fig. 5).

So far as at present known, the *Hippopotamus* is exclusively confined to the Old World, no member of the genus having as yet been met with in any Tertiary deposit on the American Continent.

We had, then, in Europe, in later Tertiary and early Quaternary times, at least two species of *Hippopotamus*, agreeing in size, and probably also in identity, with the two existing African species; whilst in India, in late Miocene or early Pliocene times, we had four species marked by differences in their dentition, and evidently belonging to an older and earlier type than the preceding.

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* In *H. sivalensis* we should have incisors $\frac{3 \quad 3}{3 \quad 3}$

† Or molars $\frac{6 \quad 6}{6 \quad 6}$.

EXPLANATION OF PLATE III.

Fig. 1. Palatal view of the skull of the recent *Hippopotamus amphibius* from Africa.
,, 2. Lower jaw of same seen from above.
(Both figures greatly reduced.)
,, 3. Palatal view of skull of *Hippopotamus sivalensis*, F. and C.
,, 4. Front or symphisial portion of lower jaw of *H. sivalensis*, showing the six incisors and the tusk-like canines.
(Both figures one-eighth natural size.)
,, 5. Molar tooth of same species, showing the worn-down double trefoil pattern of the crown (one-half natural size).

Figures 1 and 2 are taken, by permission, from Cassell's Natural History, vol. ii. p. 349, article by Prof. Boyd Dawkins and H. W. Oakley.

Figs. 3—5 are reproduced from Prof. H. A. Nicholson's Palæontology, vol. ii. p. 343, Fig. 640 (after Falconer and Cautley).

NOTICES OF MEMOIRS.

I.—Beitrag zur Kenntniss Palæozoischer Seesterne. Von B. Stürtz, in Bonn. Palæontographica, Band xxxii. 1886. Mit 7 Tafeln.

A Contribution to the Knowledge of Palæozoic Starfishes. By B. Stuertz, in Bonn. Palæontographica, vol. xxxii. pp. 75–98, pl. viii.-xiv.

FERD. ROEMER called attention[1] some years since to the echinodermal fauna occurring in the roofing slates of Bundenbach near Birkenfeld in Oldenburg, which belong to the horizon of the middle beds of the Rhenish Lower-Devonian. More particularly, Starfishes, including in the term the Asteroidea and Ophiuroidea, are abundant. The calcareous tests of these animals have been replaced by iron pyrites, and they are firmly imbedded in the hard slate in such a manner, that at the time when Roemer wrote, only the general outline of the animals could be discerned; but within the last year or two means have been found by which the slaty matrix can be entirely cleaned away, and the skeleton of the animal laid bare, so that the arrangement of the plates of the test, both on the ventral and dorsal surfaces, can be ascertained. The insight thus gained of the skeletal structure of these Devonian Starfishes has enabled Herr Stuertz to make a comparison between them and the more recent fossil and existing members of the group, and amongst other results of his work he has discovered true Ophiuroids, with a structure corresponding with that of living forms, which have not previously been known from Palæozoic strata. These were associated with the simpler Palæozoic Ophiuroids. There are also in these beds a number of true Asterids, associated with Encrinasters; and a representative of the existing genus *Astropecten*.

The single species of the *Ophiureæ veræ* belongs to the genus *Ophiurella*, Ag., and is named *O. primigenia*, St. In the group of the *Protophiureæ* are included Palæozoic Ophiuroids which possess corresponding ambulacral plates on the ventral side of the arms. The author agrees with Lütken in regarding these as doubled ventral shields, which cover the ambulacral system. In this group the author places the *Protaster Miltoni*, Salter, and *P. leptosoma*, Salter, and also a new genus, *Furcaster*, with a single species, *F. palæozoicus*, St.

Fresh observations have been made on the doubtful genus *Helianthaster*, Roemer, examples of which also occur in Devonshire as well as at Bundenbach, but they are still insufficient to determine its true position. The author regards it as an Ophiuroid Starfish with from 14–16 arms and a tolerably large disc.

The author gives the name Ophio-Encrinasteriæ to a group of forms which stand in near relationship to Ophiuroids, but possess peculiarities of structure which ally them to the Encrinasteridæ. In addition to a new genus, *Bundenbachia*, this group also includes the genera *Tæniaster*, Billings, *Eugaster*, Hall, possibly also *Ptilonaster*, Hall, and *Protaster Forbesi*, Hall, with *Protaster Sedgwicki*, Forbes.

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[1] Palæontographica, Band ix. 1862.

Under the *Asteriæ veræ*, or true Starfishes, are placed *Roemeraster asperula*, Roemer sp., *Astropecten Schlueteri*, St., *Palastropecten Zitteli*, St. n. gen. et sp., *Eoluidia Decheni*, St., n. gen. et sp., and *Protasteracanthion primus*, St. n. gen. et sp.

The following genera and species are placed in the group of the *Encrinasteriæ*: *Aspidosoma Tischbeinianum*, Roemer; *Loriolaster mirabilis*, St.; and *Palasteriscus devonicus*, St.

The species described are all figured in the accompanying plates and enlarged representations are given of their structural characters.

G. J. H.

II.—The Eocene Strata of the Krappfeld, Carinthia. By K. A. Penecke. Imper. Geol. Inst. Vienna, Meeting 17th November, 1885. Communicated by Count Marschall, F.C.G.S.

ONLY small portions of the Eocenes, resting partly on Cretaceous rocks and partly on Palæozoic schists, have escaped denudation. In one of these patches, the succession (upwards) is—

1. Lower red clays, with gravelly beds and conglomerates. 2. Modiola-marls, with, for the most part, badly preserved remains; *Modiola*, sp. (compare *crenella*, Desh.), is the most frequent. 3. Two or three seams of bright coal, with bituminous shales, containing brackish-water shells as *Faunus combustus*, Brongn., *F. undosus*, Brongn., *Melanopsis*, sp., *Planorbis*, sp., and *Cytherea Lamberti*, Desh. 4. Gasteropod-marls; similar to the foregoing marls, and abounding with well-preserved shells, as *Turritella Fuchsi*, sp. nov., *Cerithium mutabile*, *C. Canavali*, sp. nov., *Natica perusta*, and *Ostrea Canavali*, sp. nov.,; together with *Nummulites contortus*, Desh., *Serpula spirulæa*, *Modiola crenella*, *Cyrena Veronensis*, *Faunus combustus*, *F. undosus*, *Fusus longævus*, etc. 5. Nummulitic Marls. Here Gasteropods are gradually being superseded by Nummulites. The prevalent fossils are: *Orbitoides Fortisii*, *Operculina Karreri*, sp.nov., *Nummulites complanatus*, *N. perforatus*, *N. Lucasanus*, *N. contortus*, *N. exponens*, *Natica Vulcani*, and *Cerithium Canavali*. 6. Nummulitic Limestones gradually coming out of the uppermost horizon of No. 5. They contain many Echinids, Molluscs, etc., as *Alveolina longa*, *Nummulites complanatus*, *N. perforatus*, *N. contortus*, *Conoclypeus conoideus*, *Echinolampas* (comp. *Suessi*), *Pygorhynchus Mayeri*, *Linthia Heberti*, *Ostrea rarilamella*, *Velates Schmiedeliana*, *Ovula gigantea*, etc. 7. Variolarius-strata. Rather thin sands, and beds of compact sandstone, full of *Nummulites variolarius*.

Some of these beds, to a greater or less extent, are wanting, or are represented by other deposits, elsewhere in the Krappfeld. At one place some fine sands occur in the uppermost horizon of the Nummulitic Marls; and they contain good specimens of *Echinanthus tumidus*, Agass., *Linthia scarabæus*, Lbe., *L. Heberti*, Cott., and *Ottiliaster pusillus*, nov. gen. et sp. A comparison of the several sections proves the existence of two special horizons in the Krappfeld Eocenes: an upper, marine, with abundance of Nummulites, and assuming a brackish character to the north, and a lower partly brackish horizon. The fauna throughout is Lower Eocene, and has several species in common with the fauna of Ronca, and presenting some analogy to the *Sables inférieurs* of the Paris Eocenes. This fauna numbers about 85 species,—among them are 6 *Nummulites*, 4 other *Foraminifera*, 11 *Echinida*, 2 *Serpulæ*, 1 *Terebratula*, 1 *Dentalium*, 25 Bivalves, 29 Gasteropods, and 1 *Nautilus*, besides remains of Fishes and Crustaceans. The new forms are—1. *Operculina Karreri*, with conspicuous transverse ribs. 2. *Ottiliaster pusillus*, new genus of the *Echinolampas* type, the anterior ambulacra having but one series of single pores; approaching *Eolampas*, Dunc. and Slad., from Sind, India. 3. *Ostrea Canavali*, Gryphæa-like, allied to *O. cymbiola*. 4. *Arca Rosthorni*, very small, with craticulate sculpture. 5. *Corbula semiradiata*, somewhat like *Neæra radiata*, fore-part radiately ribbed. 6. *Turritella Fuchsi*, approaching *T. imbricataria*, Lamk. 7. *Natica Ottiliæ*, a small and rather indifferent form, resembling *N. Woodi*. 8. *Cheilostoma Rosthorni*, like some species from the lowermost Belgian Eocenes. 9. *Melanopsis? Reineri*; the genus uncertain, most of the specimens being crushed. 10. *Cerithium Canavali*, very near to *C. lunatum*, Mstr. 11. *Nautilus Seelandi*, very broad and inflated. 12. *Myliobates Haueri*, near to *M. goniopleurus*, Agass.

III.—THE ROCK-SALT FORMATION OF WIELICZKA, GALICIA. By J. NIEZWIECKI. Imp. Geol. Instit. Vienna, Meeting 17th November, 1885. Communicated by Count MARSCHALL, F.C.G.S.

THE borings, undertaken in order to explore the supposed westward continuation of the Salt beds, gave the following results. An alluvial deposit, 1½ meter thick, covers a grey clay (partly a marl), with seams of micaceous sand, and boulders of compact marl. This clay continued to the depth of 204½ meters, and contained some few stalks and leaves of plants, with Foraminifera (*Globigerina*, *Polymorphina*, and *Truncatulina*). This may be regarded as an eastward continuation of the sulphuriferous deposits of Swoszowice, which likewise has terrestrial plant-remains and marine shells. Coarser sand, or friable sandstone, with thin intercalations of clay, fibrous gypsum, and pieces of anhydrite, continues from 204½ to 210 meters depth. Between this and the present depth of the bore (227½ meters), saliferous clay, with scattered granular rock-salt, gypsum, and anhydrite, was pierced. Water drawn from this depth was highly saturated with salt.

IV.—GEOLOGICAL FORMATIONS IN AFGHANISTAN. By C. L. GRIESBACH, F.G.S. Imper. Geol. Inst. Vienna, Meeting 3rd November, 1885. Communicated by Count MARSCHALL, F.C.G.S.

1. PLIOCENE. Sandstones and loose sands, with great deposits of loess, and badly-preserved Mammalian remains. 2. Pliocene. Red and light-coloured clays, with beds of loess and gypsum. Nos. 1 and 2 may be equivalent to the Manchhar and Siwalik Formation

of India. 3. Miocene (and Eocene?). Thick deposits of green and red clays, with friable limestones, and salt-beds. Miocene fossils in the upper horizons. 4. Cretaceous. Inoceramus-beds, marls (mostly variegated), and limestones with Cretaceous fossils. Marine limestones abounding in organic remains. 5. Jurassic and Lias. Light-coloured sandstones and grit, with marine limestones, and plant-remains. 6. Triassic. "Red-grit Group;" an enormous assemblage of red sandstones, conglomerates, breccias, and volcanic tuffs, with intercalated eruptive rocks (mostly melaphyres), and several horizons of Brachiopod limestones. 7. Permian. Green and grey schists, sandstones and conglomerates, with "Boulder-beds," thin coal-seams and imperfect impressions of plants S.E. of Herat and in Khorassan, alternating with hard limestones, containing Brachiopods, Conchifera, and Fusulinæ. Nos. 5, 6, and 7 may possibly correspond to the Gondwana Formations of India. 8. Carboniferous (and Devonian?). Very thick, compact, grey limestones, with subordinate shales, containing *Fenestella, Productus semireticulatus, Athyris Royssyi*, etc., in the upper horizons. No. 8, answering to the Kulling strata of Cashmere, constitutes the lowermost horizon in the large folds of the Davendar, Doshatch, Bizd, and other mountain-chains.

V.—ATMOSPHERIC DUST. By Dr. M. SCHUSTER. Imper. Acad. Vienna, Meeting 14th January, 1886. Communicated by Count MARSCHALL, F.C.G.S.

THIS dust was collected at Klagenfurt in Carinthia, after a rain of muddy substance, which had taken place on the 14th October, 1885. The chief constituents of the dust are minute fragmentary crystalline granules and flakes of the following minerals:—quartz, opal, orthoclase, biotite, phlogopite, pyroxene, amphibole, light-coloured mica, talc, kaolin, chlorite, rutile, anastase, zircon, tourmaline, ferruginous clay, spinel, magnetite, pyrites, magnetic pyrites, calcite, magnesite, ferruginous dolomite, and apatite. The presence of metallic iron could not be ascertained. The microscope showed a prevalence of siliceous, silicified, and calcareous remains of organisms, especially of Diatomaceæ, either in single or in pairs, together with a few carbonaceous or carbonized substances, such as the spores of Fungi and such like, filaments of Algæ and other plants, silicified membranes of parenchymal cellules, and pyritized and silicified spherules, resembling pollen. This dust bears a great general resemblance to the atmospheric dusts described by Ehrenberg and Silvestri. The reddish-yellow colour, which it has in common with the "Passat" dust, may be an objection against its having come direct from the Sahara.

[Compare the results of Prof. Judd's examination of Nile mud, Proc. Roy. Soc. vol. xxxix. No. 240, p. 216, Nov. 1885.]

REVIEWS.

I.—A MONOGRAPH OF THE BRITISH STROMATOPOROIDS. By H. ALLEYNE NICHOLSON, M.D., D.Sc., etc., Regius Professor of Natural History in the University of Aberdeen. Part I. General Introduction, pp. iii. and 130, with 11 Plates. (Palæontographical Society's Volume for 1885.)

THE nature and systematic position of the widely-distributed groups of Palæozoic fossils, known generally as the Stromatoporæ, now styled by Prof. Nicholson "Stromatoporoids," have given rise to very varied differences of opinion, ever since the first genus was described by Goldfuss in 1826. The group has been alternately regarded as belonging to Foraminifera, Sponges, Polyzoa, Corals, and finally to Hydrozoa. Such diversities of opinion have not merely been maintained by those earlier authors, whose knowledge of the organism was limited to its form and other external features, but they have been also held by later investigators, who have studied its microscopic characters in thin sections. The opposing views may be to some extent explained by the different appearances presented by the fossils under different conditions of fossilization, by limited investigation, and in no small degree by the influence of previous lines of study on the part of the respective authors. Thus, for instance, Sir J. W. Dawson finds certain structures in Stromatoporoids resembling those in the supposed Foraminifer, *Eozoon Canadense*, and dismisses almost with contempt the view of Mr. H. J. Carter that *Stromatoporæ* are skeletons of hydroids allied to *Hydractinia*. This latter view is, however, now generally received; whilst Sir J. W. Dawson's opinion[1] that "*Stromatopora* and *Eozoon* may both be regarded as large, sessile, laminated calcareous Rhizopods," has not been supported by later authors. Prof. Sollas, on the other hand, places *Stromatopora* among the Vitreo-hexactinellid sponges, an opinion which was subsequently qualified by the statement that *Stromatoporæ* included organisms of very different affinities, some being siliceous sponges, some related to *Millepora* and *Hydractinia*, and some with relationships yet undetermined. Baron Rosén referred the group to Keratose sponges, in which the fibres had become silicified or calcified in fossilization. Prof. Nicholson also, in a joint memoir with Dr. Murie, reached the conclusion that the *Stromatoporæ* belonged to a peculiar extinct group of Calcisponges. To Mr. H. J. Carter belongs the credit of having first indicated the relationship of the *Stromatoporoids* to the recent *Hydractinia*, and their extinct allies, and this view has gradually been adopted by palæontologists generally.

The difficulties attending the study of this group of fossils may readily be inferred from the various opinions held with respect to their characters, and the present attempt to overcome the obstacles which have baffled previous observers implies no small amount of courage on the part of the author. The only sure method of investigation rests on the study of the minute structure of the skeleton, and this can only be known by means of thin microscopic sections. Of these, the author states that he has made considerably over a thousand with his own hands, whilst most of the specimens were collected by himself, from the Palæozoic strata of this country, North America, Germany, and Russia. By thus comparing the microscopic characters of all, or nearly all, the known forms of the group, under the different conditions of mineralization, it has been possible to obtain a more complete knowledge of these organisms than heretofore, and many features of importance, both as regards the structure and relationship of the group, have been discovered.

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[1] Quart. Journ. Geol. Soc. vol. xxxv. 1879, p. 50.

The first part of the Monograph contains the "General Introduction," which is treated under the following heads: (I.) Historical Introduction. (II.) The General Structure of the Skeleton. (III.) Systematic Position and Affinities of the Stromatoporoids. (IV.) Sketch Classification. (V.) Families and Genera of the Stromatoporoids. (VI.) The Nature of *Caunopora.*

(I.) Under the first head an account is given in chronological order of the various memoirs on the group. From this we learn that the type-specimen of *Stromatopora concentrica*, Goldf. (now preserved in the Bonn Museum), which is the type species of the genus, exhibits a structure greatly different from that which has generally been regarded by palæontologists as characteristic of the genus *Stromatopora.* The typical figured specimen of Goldfuss is a large mass of numerous thick concentric strata ("latilaminæ"), more or less undulating, from 1·5 to 3 mm. in thickness, and separated by narrow interspaces. Microscopic sections show that the skeleton is essentially a complex net-work of anastomosing calcareous fibres, so disposed as to inclose correspondingly complex anastomosing canals. The minute characters of this typical form had not previously been subjected to microscopical examination, and consequently the forms assigned to the genus by Bargatzky, Carter, and others, which possess structures of a different character, must necessarily be included in a new genus, which the author proposes to name *Actinostroma*, and which forms the type of the group *Actinostromidæ.*

(II.) Treating of the general structure of the skeleton of the Stromatoporoids, the author states that the typical form is that of a hemispherical mass or a flattened expansion, attached by a narrow peduncle, or directly to some foreign body, but having the under surface covered by a concentrically wrinkled imperforate epitheca, while the apertures for the emission of the polypites are carried upon the upper surface. Certain forms are ramose or dendroid, and some habitually encrust other organisms. The skeleton was originally of granular carbonate of lime, probably in the form of arragonite, but this is now replaced occasionally by silica and by crystalline calcite. One distinctive feature of the whole group of the Stromatoporoids is the constitution of the skeleton of superimposed concentric layers. In some cases these are very thick, strata-like, and made up of a series of vertical rods ("radial pillars"), which run from the top to the bottom of the stratum, and are united at irregular intervals by oblique or horizontal processes. Between the vertical rods are the tortuous, tubular, and often tabulate, canals, in which the zoöids were lodged. In other cases, the skeleton is made up of numerous closely-approximated concentric laminæ, not in absolute contact, but separated by interlaminar spaces, which are intersected by vertical columns or "radial pillars," which connect the laminæ, and may pass through several laminæ and interspaces. The calcareous fibres of the skeleton are probably in no case compact, sometimes they are filled with what appear to be minute pores or vesicles, at others by complex ramifying tubuli. Nothing of the nature of definite spicules has been noticed in any example of the group.

According to the general arrangement of the "radial pillars" and "concentric laminæ" two principal sections of Stromatoporoids are distinguished, the Milleporoid and Hydractinioid sections. In the first of these, represented by the genus *Stromatopora*, Goldfuss, the radial pillars and concentric laminæ are completely amalgamated, and, as a rule, cannot be recognized as distinct structures. Tangential sections of the skeleton appear to be continuously reticulate, resembling that of *Millepora*, whilst in vertical sections the radial pillars appear as thick, irregular and flexuous, and the concentric laminæ are only represented by irregular lateral outgrowths, which spring from the pillars and unite them into a continuous framework. In the "Hydractinioid" section, represented by the genus *Actinostroma*, the radial pillars and concentric layers are present as distinct, though closely connected structures. In vertical sections of *A. clathratum*, the skeleton appears as a series of parallel vertical rods, nearly equi-distant from each other and connected at regular intervals by a series of parallel horizontal laminæ. In a tangential or horizontal section, the transversely-divided ends of the radial pillars appear as rounded or stellate dots, placed at tolerably regular intervals. The radial pillars give out at regular intervals, verticils of horizontal connecting processes or arms, which join one another to form a complete network. and the concentric laminæ are, in reality, formed of these united horizontal processes. When the section passes through the plane of one of the concentric lamina, the cut ends of the radiate pillars have a stellate form, and their united arms form an angular mesh-work, not unlike that of a hexactinellid sponge, but if the section is through the interlaminar spaces, then only the cut ends of the radial pillars are visible. Thus the concentric lamina is, in reality, merely a porous mesh-work, through the openings of which in the upper layer the zoöids could extend.

In the genus *Clathrodictyon*, Nich. and Murie, the radial pillars are incomplete or almost obsolete, whilst in *Labechia* they are highly developed. The author states that the radial pillars are not invariably solid, a minute central canal can be detected in many, but even where this exists, it does not appear to have been open at the summit. There is no ground for the supposition that the pillars were inhabited by zoöids, or that they can be compared in any way with the zoöidal tubes of *Millepora*. In one singular form, *Hermatostroma*

Schluteri, there are large canals in the radial pillars, which send out branches into the connecting processes forming the concentric lamina, and this fact indicates that the fibres of the concentric lamina generally may be hollow.

One obstacle to ranging the Stromatoporoids with the *Cœlenterata* has been the apparent absence of any tubes for the lodgment of the zoöids, but the author has made the important discovery that the skeleton of the typical *Stromatoporæ* is penetrated by numerous minute, flexuous, but essentially parallel, vertical tubes, which are not bounded by definite walls, but simply inclosed by the vermiculate fibres of the cœnosteum, precisely like the zoöidal tubes in *Millepora*. Further, these tubes are traversed at intervals by calcareous plates, similar to those of *Millepora* and tabulate corals. These tabulate zoöidal tubes can be clearly distinguished in different species of *Stromatopora*, and also in such genera as *Idiostroma*, Winch., and *Stachyodes*, Barg. Definite tubes are not clearly recognizable in the Hydractinioid section of the group, but there are zoöidal cavities in *Actinostroma*, and in *Labechia* it is probable that the zoöids were given off from the surface layer of the cœnosarc.

The author agrees with Mr. Carter in recognizing the stellate canal system on the surface of the concentric laminæ as the homologue of the branching of the cœnosarcal grooves on the surface of the skeleton of many Hydractiniæ, and adopts for it Mr. Carter's term Astrorhizæ. These canals, though not invariably present, are yet found in so many different forms of the group, that they cannot be accepted as of generic value, and consequently the genus *Cænostroma*, Winchell, in which they are regarded as an essential character, cannot be retained.

In some anomalous, cylindrical or dendroid, Stromatoporoids, placed in the genera *Idiostroma*, *Amphipora*, and *Stachyodes*, there is a central, axial, tabulated tube, without proper wall, giving off at times lateral branches, which also divide. These "axial tubes" are quite distinct from those of the so-called *Caunopora*, and the author thinks they may have lodged a stolon or axis of the cœnosarc, and that the smaller lateral tubes may have been occupied by a special series of zoöids.

Certain large-sized lenticular vesicles, resembling the "ampullæ" of the recent *Stylasteridæ*, are present in *Amphipora ramosa*, Phill. sp., and may probably have lodged the reproductive zoöids, and large tabulated vesicles in *Idiostroma capitatum*, Goldf. sp., may also have served for the same purpose.

(III.) *Systematic Position and Affinities.*—The author frankly accepts the views of Carter, Lindström, Zittel, and others as to the cœlenterate affinities of the Stromatoporoids, and regards them as a special group of the *Hydrozoa*, having relationships on the one hand with *Hydractinia*, and on the other with *Millepora*. A detailed comparison between *Hydractinia echinata*, Flem., and forms of *Actinostroma*, Nich., shows that there is a remarkable similarity between the minute structure of the chitinous skeleton of the former organism and the large calcareous cœnosteum of the latter; and a similar but not so striking a resemblance is also seen when the comparison is made with the *Hydractinia circumvestiens* from the Red Crag of Suffolk, which possesses a calcareous cœnosteum. The typical Stromatoporæ, on the other hand, are more closely comparable with the cœnosteum of *Millepora.* But as both the groups of Stromatoporoids are linked together by intermediate forms, and thus constitute a natural series, it is better to retain these fossils as a peculiar division of the *Hydrozoa*

(IV.) *Sketch Classification.*—This is to be accepted as largely tentative, as many of the types have not yet been properly examined. The following tabular view is given by the author.

Order.—STROMATOPOROIDEA, Nich. and Murie.
Section A. ("Hydractinioid" Group).
Fam. 1. Actinostromidæ, Nich.

Genera—*Actinostroma*, Nich.; *Clathrodictyon*, Nich. and Murie; *Stylodictyon*, Nich. and Murie (?).

Fam. 2. Labechiidæ, Nich.

Genera—*Labechia*, E. & H.; *Rosenella*, Nich.; *Beatricea*, Bill. (?); *Dictyostroma*, Nich. (?).

Section B. ("Milleporoid" Group).
Fam. 3. Stromatoporidæ, Nich.

Genera—*Stromatapora*, Goldf.; *Stromatoporella*, Nich.; *Parallelopora*, Barg. (sub-genus?); *Syringostroma*, Nich. (sub-genus?).

Fam. 4. Idiostromidæ, Nich.

Genera—*Idiostroma*, Winch.; *Hermatostroma*, Nich.; *Amphipora*, Schulz; *Stachyodes*, Barg.

(V.) *Families and Genera of the Stromatoporoids.*—Detailed descriptions are given of the characters of the various members of the group, to which space prevents further reference, but the inclusion of the peculiar forms known as *Beatricea*, Bill., as a genus of Stromatoporoids, calls for some notice. These fossils are cylindrical or angulated rods or stems, often of considerable size, some reaching 10 feet in length by one foot in thickness. They possess a central, relatively large, axial canal, without definite walls, and divided by superposed, curved, tabulæ. Between the central canal and the exterior of the fossil, the skeleton consists of concentric layers of vesicular tissue. The position of these fossils has long been regarded as uncertain, and one observer, Prof. Hyatt, who formerly referred the genus to the *Cephalopoda*, now degrades it to the *Foraminifera.* The general opinion has been in favour of its alliance to the Cystiphylloid Corals. The fossils are generally very imperfectly preserved, but Prof. Nicholson has detected, in some specimens, structures radiating from the central canal towards the circumference, which he regards as "radial pillars" essentially similar to those of the genus *Labechia.* The axial tabulate tube is regarded as parallel with the tubes in *Idiostroma, Stachyodes*, and *Amphipora.* But the axial tubes in these forms are so much smaller than those of *Beatricea*, that whilst it may seem reasonable to suppose that the former were occupied by a stolon or axis of the cœnosarc, the same explanation will hardly suffice for the latter, in which the axial canal is sometimes 10 mm. in diameter. On the whole, whilst fully appreciating the significance of the facts brought forward by Prof. Nicholson, we should feel disposed to wait for further evidence before definitely accepting *Beatricea* as a genus of Stromatoporoids.

(VI.) *The Nature of Caunopora.*—The author discusses in detail the much-debated subject of the nature of the Stromatoporoids, in which the cœnosteum is traversed by thick-walled tubes at right angles to the concentric laminæ of the fossil. These tubes are frequently tabulate, and in some cases they possess spines resembling the spinal septa of *Favosites* or *Syringopora*, and they are usually all connected together and open into each other, whilst at the same time no communication can be traced between them and the interlaminar spaces of the *Stromatopora* itself. Prof. Nicholson has established the fact that in several distinct species of *Stromatopora* and *Stromatoporella*, there are two states of the same species occurring in the same locality, one, in which the so-called "*Caunopora*" tubes are present, and the other in which these structures are entirely wanting. It follows from this, that the existence of these tubes can in no wise characterize a particular genus, and therefore the names of *Caunopora*, Phill., and *Diapora*, Barg., must be abandoned.

In character these "Caunopora" tubes closely resemble the tubes of *Syringopora* and *Aulopora*, and by Rœmer, Carter, and others they are believed to be independent organisms enveloped in the growth of the Stromatopora. There are certain difficulties against the acceptance of this theory; one is the fact, that many of these tubes are not known independent of their Stromatopora envelopment. The "Caunopora" tubes often occur also in localities where independent forms of *Syringopora* are altogether absent, and on the other hand, where the corals are abundant, the "Caunopora" forms of Stromatopora are rare. It is possible that, owing to the commensal mode of growth, distinct forms of *Syringopora* and *Aulopora* may have been produced. The author arrives at the conclusion that "the fossils ordinarily called '*Caunoporæ*' and '*Diaporæ*' are the result of the combined growth of some Stromatoporoid with some Coral, the former usually being a species of *Stromatopora* or *Stromatoporella*, and the latter generally belonging either to *Syringopora* or to *Aulopora*."

In concluding this notice, we may call attention to the beautiful plates in which the minute structures of the organisms described are fully illustrated. The plates have been drawn by the author and lithographed by Mr. Hollick. This first part of the Monograph needs no commendation. It is a very important contribution to the knowledge of a most puzzling group of organisms, and the subject is treated with that thoroughness which specially characterizes Prof. Nicholson's work. G. J. H.

II.—REPORT ON THE INVERTEBRATA OF THE LARAMIE AND CRETACEOUS ROCKS OF THE NORTH-WEST TERRITORY. Contributions to Canadian Palæontology. By J. F. WHITEAVES, F.G.S., etc. Palæontologist and Zoologist to the Survey. Vol. I. Part 1. 8vo. pp. 89 and 6 Plates. (Montreal, Dawson Bros., 1885.)

UNDER the title of 'Contributions to Canadian Palæontology,' it is proposed to publish such papers as cannot be conveniently included in either of the volumes on the Palæozoic or Mesozoic Fossils of Canada, now in course of preparation. This first part contains a determination of the marine, brackish, and freshwater invertebrate fossils —with one exception, all mollusca—collected by Dr. G. M. Dawson and others in the North-west Territory of Canada. Many of these fossils have already been described by Messrs. Meek and Hayden and other United States palæontologists, and of these reference is made to the synonymy, and the localities are given where they occur. The new forms are fully described and figured. They include *Unio Albertensis*, *Anomia perstrigosa*, *Corbicula obliqua*, *C. perangulata*, *Panopæa simulatrix*, *P. curta*, *Acella*, sp., *Physa Copei*, var. *Canadensis*, *Acroloxus radiatulus*, *Patula angulifera*, *P. obtusata*, *Anchistoma parvulum*, *Valvata filosa*, *V. bicincta*, *Gervillia recta*, var. *borealis*, *Modiola dichotoma*, *Cyprina ovata*, var. *alta*, *Protocardia borealis*, *Panopæa subovalis*, *Scaphites subglobosus*, *Crenella* (?) *parvula*, *Unio supragibbosus*, *Rhytophorus glaber*, *Planorbis paucivolvis*, *Hydrobia subcylindracea*, and the solitary Crustacean *Hoploparia ? Canadensis*.

The rocks from which these fossils have been obtained are fully described by Dr. G. M. Dawson in the Report of Progress of the Geological Survey of Canada, 1882–4. In the Laramie Group are included, (1) Porcupine Hill beds, of freshwater sandstones and shales —2500 feet; (2) Willow Creek beds, also freshwater—450 feet; (3) St. Mary River Series, nearly all freshwater—2800 feet; thus making a total thickness of 5750 feet of strata assigned to the Laramie Group. In the underlying (so-called) Cretaceous series the following subdivisions are made: (*a*) Fox Hill Sandstones, brackish-water, 80 feet; (*b*) Pierre shales, marine, 750 feet; (*c*) Belly River series, 910 feet; (*d*) Lower dark shales, 800 feet; in all a total thickness of 2540 feet. The stratigraphical disposition adopted by Dr. G. M. Dawson of a Cretaceous series and an upper series—the Laramie— of extra Cretaceous rocks, is not, according to Mr. Whiteaves, supported by the palæontological evidence. This author states that the "invertebrate fauna of the 'Belly River series' seems to be essentially the same as that of the Laramie of the United States and Canada, unless more than one formation has been confounded under the latter name, and that it is at present scarcely possible to separate the 'Lower Dark Shales' of Dr. Dawson's Report from the 'Fort Pierre and Fox Hill Groups' on purely palæontological grounds." If this statement is correct, that the fossils of these two important series of strata are similar, it would be interesting to know the reasons which have led to the separation of the Laramie division from the Cretaceous in Canada. G. J. H.

III.—PUBLICATIONS OF THE PALÆONTOGRAPHICAL SOCIETY, LONDON. 4to. Vols. XXXIII.—XXXIX., 1879—1885. President: Sir Richard Owen, K.C.B., M.D., D.C.L., LL.D., F.R.S., F.G.S., etc. Secretary: Professor T. Wiltshire, M A., F.G.S., 25, Granville Park, Lewisham, S.E. Treasurer: Robert Etheridge, Esq., F.R.S., F.G.S., British Museum (Natural History), Cromwell Road, S.W.

THE Palæontographical Society was established in the year 1847, for the purpose of figuring and describing the *whole* of the British fossils. Each person subscribing ONE GUINEA is considered a Member of the Society, and is entitled to the Volume issued for the year to which the subscription relates.

Surely this is a Society that has the highest possible claims upon the consideration of every geologist, who must, as a matter of course, be deeply interested in the past Life-history of the Earth whose crust he is bound, hammer in hand, to explore,

It seems rather surprising that only 475 Members should at present be found willing to subscribe an annual guinea for so grand a publication, one which, in a mere mercantile sense, is *richly worth two guineas*, in a scientific point of view, would be cheap at four guineas a year!

The following is a summary of the contents of the last seven volumes issued:—

Vol. XXXIII. for the year 1879, contains:—

The Eocene Flora, Part I. by Mr. J. S. Gardner and Baron Ettingshausen, 5 plates.—Second Supplement to the Crag Mollusca (Univalves and Bivalves), by Mr. S. V. Wood, 6 plates. (Complete with Title page and Index).—The Fossil *Trigoniæ*, No. V. (*Conclusion*), by Dr. Lycett, 1 plate.—The Lias Ammonites, Part II. by Dr. Wright, 10 plates.—Supplement to the Reptilia of the Wealden (*Goniopholis*, *Brachydectes*, *Nannosuchus*, *Theriosuchus*, and *Nuthetes*, No. IX. by Prof. Owen, 4 plates.—The Fossil Elephants (*E. primigenius*), Part II. by Prof. Leith Adams, 10 plates.

Vol. XXXIV. for 1880, comprises:—

The Eocene Flora, Part II. by Mr. J. S. Gardner and Baron Ettingshausen, 6 plates.—The Fossil Echinodermata, Oolitic, Vol. II. Part III. (Asteroidea and Ophiuroidea), by Dr. Wright, 3 plates. (Complete).—Supplement to the Fossil Brachiopoda, III. (Permian and Carboniferous), by Mr. Davidson, 8 plates.—The Lias Ammonites, Part III. by Dr. Wright, 22 plates.—The Reptilia of the London Clay, Vol. II. Part I. (*Chelone*) by Prof. Owen, 2 plates.

Vol. XXXV. for 1881, embraces:—

The Fossil Echinodermata, Cretaceous, Vol. I. Part IX. by Dr. Wright, 6 plates.—Supplement to the Fossil Brachiopoda, Part IV. (Devonian and Silurian, from Budleigh-Salterton Pebble Bed), by Dr. Davidson, 5 plates.—The Fossil Trigoniæ (Supplement to No. 1), by Dr. Lycett.—The Lias Ammonites, Part IV. by Dr. Wright, 10 plates.—The Reptilia of the Liassic Formations, Part III. (*Conclusion*), by Prof. Owen, 13 plates.—The Fossil Elephants (*E. primigenius* and *E. meridionalis*), Part III. (*Conclusion*), by Prof. Leith Adams, 13 plates.

Vol. XXXVI. for 1882 includes:—

The Eocene Flora, Vol. I. Part III. (*Conclusion*), by Mr. J. S. Gardner and Baron Ettingshausen, 2 plates.—Third Supplement to the Crag Mollusca, by the late Mr. S. V. Wood, 1 plate. (Complete).—The Fossil Echinodermata, Cretaceous Vol. I. Part X. (*Conclusion*), by Dr. Wright, 5 plates.—Supplement to the Fossil Brachiopoda, Vol. IV. Part V. (*Conclusion*), by Dr. Davidson.—Supplement to the Fossil Brachiopoda, Vol. V. Part I. (Devonian and Silurian), by Dr. Davidson, 7 plates.—The Lias Ammonites, Part V. by Dr. Wright, 22 plates.

Vol. XXXVII. for 1883, contains:—

The Eocene Flora, Vol. II. Part I. by Mr. J. S. Gardner, 9 plates.—The Trilobites of the Silurian, Devonian, &c., Formations, Part V (*Conclusion*), by the late Mr. J. W. Salter.—The Carboniferous Trilobites, Part I. by Dr. H. Woodward, 6 plates.—Supplement to the Fossil Brachiopoda, Vol. V. Part II. (Silurian), by Dr. Davidson, 10 plates.—The Fossil Trigoniæ (Supplement No. 2), by the late Dr. Lycett, 4 plates. (Complete).—The Lias Ammonites, Part VI. by Dr. Wright, 8 plates.

Vol. XXXVIII. for 1884, comprises:—

The Eocene Flora, Vol. II. Part II. by Mr. J. S. Gardner, 11 plates.—The Carboniferous Entomostraca, Part I. No. 2 (*Conclusion*), by Prof. T. Rupert Jones, Mr. J. W. Kirby, and Prof. G. S. Brady, 2 plates.—The Carboniferous Trilobites, Part II. by Dr. H. Woodward, 4 plates. (*Conclusion*).—Supplement to the Fossil Brachiopoda, Vol. V. Part III. (*Conclusion*), by Dr. Davidson, 4 plates.—The Lias Ammonites, Part VII. by Dr. Wright, 10 plates.

Vol. XXXIX.* for 1885, embraces:—

1. The Eocene Flora, Vol. II. Part III. (*Conclusion*), by Mr. J. S. Gardner, F.G.S., with 7 plates.—2. The Stromatoporoids, Part I. by Prof. H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E., F.G.S., with 11 plates.—3. The Fossil Brachiopoda (Bibliography), Vol. VI. (*Conclusion*). by the late Dr. Davidson, F.R.S., and Mr. W. H. Dalton, F.G.S.—4. The Lias Ammonites, Part VIII. (*Conclusion*), by the late Dr. Wright, F.R.S., with 1 plate.

From this it will be seen that seventeen Monographs are brought to a conclusion and have their Indices and Title-pages provided for them; whilst fresh Monographs are announced as in progress, On the Fossil Tertiary Plants, by J. Starkie Gardner, F.G.S.—On the Coal-Plants, by Prof. Williamson, F.R.S., of Manchester.—On the Stromatoporoids, by Prof. H. Alleyne Nicholson, M.D., F.R.S.E.,† etc.—On the Fossil Sponges, by Dr. G. J. Hinde, F.G.S.—On the Gasteropoda of the Jurassic Rocks, by Wilfrid H. Hudleston, M.A., F.R.S., F.L.S., F.G.S. — On the Oolitic Cephalopoda, by Mr. J. Buckman.—On the Phyllopoda of the Palæozoic rocks, by Professor T. Rupert Jones, F.R.S., F.G.S.—On the Entomostraca of the Cretaceous formation, by Prof. T. Rupert Jones, F.R.S., F.G.S., and Dr. G. J. Hinde, F.G.S.—On the Trilobita of the Silurian and Cambrian formations, by Henry Woodward, LL.D., F.R.S., F.G.S., and On British Fossil Malacostraca, by the same author.—The Graptolites of the Cambrian and Silurian formations, by Prof. Charles Lapworth, LL.D., F.G.S., etc.—The Fishes of the Carboniferous Formation, by Dr. R. H. Traquair, F.R.S., F.G.S., etc.

Other Monographs are no doubt forthcoming; but with such an attractive bill of fare for the present and future years, who, that is interested in palæontology, can withhold his subscription in support of so splendid and National a work?

REPORTS AND PROCEEDINGS.

I.—Royal Geological Society of Ireland. (Abstract.)

At the Anniversary Meeting on the 17th inst. (February) a paper was read by Mr. A. B. Wynne, F.G.S., "On some recent discoveries of interest in the Geology of the Punjab Salt Range."

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* Completed and ready for issue on February 15th, 1886. † See ante, pp. 123-128.

The author refrained from attempting any lengthened treatment of so large a subject as the geology of this region, having already contributed various reports and papers to the mass of information existing in some forty publications which formed the geological literature of the Range during the last fifty-seven years. Of these numerous publications, some, if not absolutely mythological, trenched largely upon the limits of romance; some, like Dr. Fleming's, were most valuable records of close scientific observation; and others, such as Dr. Jameson's, possessed historic interest, and showed the difficulties under which the pioneers of geological research explored that country. This officer related how—in his progress through the then native territory of the Salt Range, etc., in order to investigate the causes of those *debacles* which sometimes carry devastation along the course of the Upper Indus towards the Plains—his party was beset in the Kotul Pass in the year 1841, his followers killed, and his personal effects and MS. notes all plundered by Afrídí robbers, he himself escaping with his life only to be imprisoned in the fort at Kohát.

Some reference to the position, etc., of the Salt Range was necessary, in order that people at this distance from that locality—some 5000 to 6000 miles—might more readily comprehend the references to be made. The Range was described as subtending that angle of Northern India embraced between the Great Himálayan and Suliman Mountains. It would almost appear to have yielded to the thrust from these vast masses at each end so as to have assumed curvature amounting to sigmoid flexure along the strike, in the effort to adapt itself, so to speak, to restricted limits; while its geological series forming a semi-anticlinal arch, as a dominant feature, presented a grand façade of precipices with a general height of 2000 feet, and a culminating one of over 5000 feet above the sea; overlooking the plains and deserts to the south, and rising from amongst chaotic masses, the wreckage and ruins of their own materials. On the north it sloped more gently beneath the elevated steppe-like plateau of Rawul Pindi, this having a height of 1600 to 1700 feet above sea-level.

The range possesses interest geologically, as affording almost the only opportunity of studying an extensive series, embracing groups belonging to nearly all the chief periods from early Palæozoic to later Kainozoic time; geographically interposed between the remarkably dissimilar geological areas of Peninsular India and the Himálaya, each of which had a geological history peculiarly its own. But the Salt Range was also important by reason of the great value of its inexhaustible mineral resources; its 500 feet of rock salt beds, traceable for 130 miles, producing an increasing annual revenue, some years since estimated at over £382,650 sterling; resources which now require a special branch railway and bridge across the River Jhélum (the ancient Hydaspes) to transport the salt.

Certain varieties in the relative fullness of the sections displayed at the centre and at each end of the Range were described, such as the limitation of the "Carboniferous or *Productus* Limestone" to the west of the Range: a formation also remarkable for its having afforded the earliest known *Ammonite* and the peculiar Brachiopoda *Lyttonia* and *Oldhamini* (Waagen), found only in two other, distant, Eastern localities, one of them being in China. The last-named of these forms had been previously described as a *Bellerophon*, whilst the rugose interior aspect of the larger valves of *Lyttonia* had been regarded as fish teeth.

Attention was called to the absence of any recognizable Devonian group in the Range and to the recent interesting discovery by Dr. H. K. Warth, Ph.D., Indian Public Works Department, of what are claimed to be Devonian fossils; particularly those of the genus *Conularia*; inclosed both as rolled fragments in the matrix and also in derivative pebbles, within a certain conglomerate-layer, traceable for miles in the eastern part of the Range above the Mayo Salt Mines, and included in the upper part of an olive group of rocks referred by Dr. W. Waagen and the author, when jointly classifying the Salt Range series, to a presumably Cretaceous horizon. Specimens of the *Conularia* were exhibited, which, on being compared with a published figure of *Conularia ornata* from the Devonian formation, presented a striking identity, but no published determination of these Salt Range forms was as yet known.

It was pointed out that none of the Himálayan or other neighbouring rocks (including those of the Salt Range) contained any established Devonian horizon, nor any beds with which the pebbles containing these fossils could be actually identified. Still their pale colour might suggest that they came from some part of a very pronounced group in the lower part of the series which had been called the "Magnesian Sandstone Division," resting upon the Silurian or "*Obolus* zone." The group had, however, hitherto proved quite unfossiliferous.

Turning unwillingly from this conjecture, if another origin for the pebbles were to be sought, the next most possible supposition would be that the parent rock lay to the south and belonged to a land long since buried beneath the alluvial plains and deserts which stretched southwards into Scind—a land perhaps connected with the lost continent of Lemuria, supposed to have united India with Africa.

One small group of hills called the Korana Hills projects from the plains of the Chenab river, about forty miles southward of the Salt Range; these had been visited by both Dr. Fleming and by Mr. Theobald. Their dark slaty rocks, however, as described by those gentlemen, afford no clue to the identification of the derived *Conularia* pebbles, and present no similarity either to any belonging to the Salt Range.

Instances of the occurrence of other detrital deposits in the Range, the coarse materials of which were likewise untraceable amongst the surrounding rocky tracts, were alluded to as strengthening the supposition of a lost continent to the south, which had furnished hard metamorphic detritus at various periods in the history of the Salt Range. These deposits were found immediately overlying the salt and gypseous marl at the base of the series: again near the Silurian horizon, and in the "Olive group" with the *Conularia* layer, but lower in position. From these Mr. Theobald had obtained at least one glaciated boulder. A still newer band marked by boulders of a red granite, the source of which was quite unknown, occurred in the Tertiary beds above the Eocene Limestone of the Range.

The interest of Dr. Warth's discovery was enhanced by the conspicuous absence of known Devonian rocks among the formations of Northern India, if not from Indian series generally, and in the hope that some further determinations would be made, the specimens kindly sent from the Punjab by Dr. Warth were handed over by the author to the Museum of Trinity College, Dublin, through its Curator, the Professor of Geology, etc., W. J. Sollas, D.Sc., LL.D., who promised attention to the subject, and noted much similarity between the contents of the Salt Range Cretaceous deposits and conditions, and those of Cambridge.

II.—Belfast Natural History Society.

Mosasaurus gracilis, Owen, from the Irish Chalk.

At a meeting of the Belfast Natural History and Philosophical Society, held in their museum on Tuesday, February the 2nd, the President, W. H. Patterson, Esq., M.R.I.A., in the Chair, a short communication was brought forward by Mr. W. Swanston, F.G.S., on the occurrence of remains of *Mosasaurus gracilis*, Owen, recently presented to the Museum by Mr. Turner, Mountain Bush, in whose quarries at Whitewell the specimen was found. The fossil is portion of the caudal vertebræ, consisting of three joints attached, very closely resembling the specimen figured in the Palæontographical Society's Journ. 1851, vol. viii. fig. 3. This is the first record of the species from Irish strata. The quarries from which the specimen was obtained are in the White Limestone (Upper Chalk), most probably the zone of *Ammonites Gollevillensis*, representing, according to Professor Ralph Tate, F.G.S., the Upper Chalk of Norwich, and the "Craie de Meudon," and some of its fossils point to even a higher parallel, that of the Maestricht Chalk (Quart. Journ. Geol. Soc. London, 1865, vol. xxi. p. 36).

III.—Geological Society of London.

I.—Jan. 27, 1886.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Fossil Mammalia of Maragha, in North-western Persia." By R. Lydekker, Esq., B.A., F.G.S., etc.

The author alluded to the important memoirs of Messrs. Grewingk, Pohlig, and Rodler on the Maragha mammalia, and having expressed the hope that his notice would be regarded as an attempt to assist rather than to interfere with their work, mentioned a collection of specimens from Maragha sent by Mr. Damon to the British Museum. He fully confirmed the conclusions already arrived at as to the identity of many of the Maragha mammals with those of Pikermi, and thought that *Giraffa attica*, *Palæoryx Pallasi*, *Sus erymanthius*, *Mastodon pentelici*, and *Helladotherium Duvernoyi* might be added to the list of species already recorded. He also recorded the French *Felis brevirostris*; a *Rhinoceros*, apparently allied to *R. antiquitatis*; and *R. Blanfordi*, of the north-west portion of India and China. The paper concluded with some observations regarding the relations of the Palæarctic and Oriental Pliocene faunas.

2. "On the Pliocene of Maragha, Persia, and its resemblance to that of Pikermi, in Greece; on Fossil Elephant-remains of Caucasia and Persia; and on the results of a Monograph of the Fossil Elephants of Germany and Italy." By Dr. H. Pohlig. Communicated by Dr. G. J. Hinde, F.G.S.

The principal object of the author in making a geological tour through part of Persia, in 1884, was the exploration of a deposit containing Pliocene mammals, discovered thirty years ago near Maragha, east of Lake Urumia, by Göbel and Khanikoff. The first part of the present paper gives a brief account of the results of this exploration, together with a list of the fossils.

The ossiferous deposits near Maragha are of fluvio-lacustrine origin, and consist chiefly of reddish marls, similar to those of Pikermi, and formed from the detritus of the volcanic mountain of Sahend. These Pliocene beds rest upon horizontal Cretaceous strata, and pass upwards into Pleistocene deposits with erratic blocks.

In the list of fossil mammalia it is shown that several are the same as Pikermi forms. A *Hipparion*, probably identical with *H. gracile*, is the most abundant. The supposed occurrence of Pleistocene forms, such as *Rhinoceros tichorhinus*, associated with the Maragha Pliocene fossils, is probably an error.

The second part of the paper contains notes on specimens of *Elephas primigenius*, chiefly in the Museum of Tiflis. The third part gives very briefly the principal results of the author's examination of Pleistocene *Proboscidea* in the various museums of Europe, especially in those of Germany and Italy, and concludes with his views with respect to *Elephas antiquus*, *E. melitæ* (which he considers a dwarf form of *E. antiquus*), *E. meridionalis*, *E. hysudricus* (which the author considers identical with *E. meridionalis*), *E. primigenius*, and a few other species, one of which is believed to be new.

3. "The Thames Valley Surface-deposits of the Ealing District and their associated Palæolithic Floors." By John Allen Brown, Esq. Communicated by A. Ramsay, Esq., F.G.S.

The author stated that his paper might be regarded as in some degree supplementary to that by Colonel Lane-Fox, published in the Quarterly Journal of the Society in November, 1872. He referred to Mr. Whitaker's division of the Thames-valley deposits into three terraces, namely:—1. The lowest now seen in bends of the river, 10–20 feet above O. D.; 2. The middle terrace, 20–40 feet; and 3. The high-terrace gravel, 50–100 feet, extending up to the shoulders of the hills, and, according to the author, much higher. The high-terrace gravels near Ealing reach nearly to the top of the hills forming the inner valley-ridge, the highest point in which is the Mount at Ealing, 204 feet. The summit of this, when excavated for a reservoir, was found to be occupied by thick beds of gravel of different character from the valley-gravels, and not of fluviatile or estuarine formation; the same gravel occurs upon other elevations, and patches of it, appearing here and there, show that it probably once extended right along the ridge and over Hanger Hill. Similar materials to those forming this gravel also occur scattered over the surface of the ground. On the Mount these gravels filled a series of furrows or channels, beneath which were horizontally stratified deposits of white sand, loam, and loamy clay, which were pressed out of the line of deposit where the jagged furrows occurred; and from all the characters presented the author inferred that these deposits were due to the action of ice which had stranded and melted here, and deposited its burthen of glacial detritus. The author described the deposits of gravels, brick-earth, etc., at various points in the district, and noticed that the high-terrace gravels between 60 and 125 feet contain seams of black matter, apparently due to the decay of vegetable substances, which recur at more or less regular intervals, and serve to indicate three or four lines of old land-surfaces. In connexion with these land-surfaces, especially in some pits excavated in the Creffield Road, about 100 feet above O. D., numerous worked flints were found, the characters and mode of association of which led the author to think that we have here traces of a regular manufactory of flint implements. He further indicated the conditions under which he considered their preservation in this locality had taken place.

II.—Feb. 10, 1886.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On a new species of *Psilotites* from the Lanarkshire Coal-field." By R. Kidston, Esq., F.G.S.

The specimen described, which was found by Mr. Walter Burns in 1884, consists of three parallel branchlets with thorn-like projections on one side only. The author describes these as a form of Goldenberg's genus *Psilotites*, and points out that they have much resemblance to Dawson's *Psilophyton*.

2. "The Melbourn Rock and the Zone of *Belemnitella plena*, from Cambridge to the Chiltern Hills." By W. Hill, Esq., F.G.S., and A. J. Jukes-Browne, Esq., F.G.S.

The "Melbourn Rock," which was first defined by one of the authors in 1880, is a band of rocky chalk which forms the base of the Middle Chalk in Cambridgeshire, and occurs about 80 feet above the "Totternhoe Stone." In the present paper it was shown, as the result of the mapping operations of the Geological Survey, to form a well-marked and constant feature in the counties of Hertford, Bedford, Buckingham, and Oxford. In the original description of the Melbourn Rock it was confounded with the "Zone of *Belemnitella plena* in a *remanié* condition," as described by Dr. Barrois; but it was now pointed out that the latter horizon is distinct from and underlies the latter. Although the zone of *Belmnitella plena* has been very largely removed by erosion in the district described, there is, nevertheless, evidence that this erosion has gone on to a different extent in each of the localities which have been particularly studied; and in some places some of the lower portions of the rocks of that horizon seem to have escaped denudation.

The microscopical characters of the several varieties of rock forming the Lower and Middle Chalk of the district were described, and it was shown that the beds containing nodules of a different variety of chalk which occur below the Melbourn Rock, may have been formed by the washing away of the finer particles from a disintegrating mass of chalk. This mottled chalk and the overlying Melbourn Rock are very similar to the bed found on the same horizon in the Richmond well. Somewhat similar beds occur, however, at other horizons in the Chalk over the district described in this paper.

3. "On the Beds between the Upper and Lower Chalk of Dover, and their comparison with the Middle Chalk of Cambridgeshire." By W. Hill, Esq., F.G.S.

In introducing the subject of this paper, the author referred to the divisions of the Upper Cretaceous series given in the 'Geology of the Neighbourhood of Cambridge' by Messrs. Penning and Jukes-Browne. The Middle Chalk was there described as separated from the Lower by the Melbourn Rock, which also appeared to coincide with a marked palæontological break, and from the Upper Chalk by the well-known Chalk Rock, this rocky bed, 10 feet in thickness, being included in the Middle Chalk. The division thus made corresponded exactly with the Turonian of French authors.

The author, giving a description of the Middle Chalk seen in the cliffs east and west of Dover, stated that the grit bed of Mr. Price, though much thicker, had all the appearance and structure of the Melbourn Rock, and this, with less hard, but still nodular, chalk above, appeared to be the equivalent of the zone of *H. Cuvieri* in Cambridgeshire. The zone of *Terebratulina gracilis* is well marked in the Dover cliffs, and is equal in thickness to that zone as described in the Cambr. Mem., viz. 150 feet. Above this zone the Chalk became harder, weathered, with lumpy projections, and finally passed into a series of rocky layers. separated by courses of softer chalk, containing, however, hard crystalline lumps. The passage to this rocky chalk was marked by the occurrence of *Holaster planus* (zone of *H. planus*). The rocky layers, extending upward for 80 feet, were marked by the presence of numbers of Micrasters, "Chalk with many Micrasters" of the author. His division included all the nodular chalk of Dover, the "chalk with many organic remains" of W. Phillips, and in it were found the fossils recorded as peculiar to Chalk Rock in the Geol. of Cambridgeshire. It appeared divisible into two zones; the lower, 15 feet, with *Micraster breviporus* (zone of *M. breviporus*), may be considered by some to be an extension of the zone of *H. planus*, the form which marks the passage from the soft to the hard chalk. In the remainder *M. cor-testudinarium* was common (zone of *M. cor-testudinarium*).

Seen in thin sections under the microscope, the structure of the hard beds which mark the limits of the Middle Chalk was stated to be very similar.

In conclusion, the author considered that the divisions of the Middle Chalk, as set forth in the Cambr. Memoir, are well shown in the cliffs of Dover; but the hard beds which appeared to him the equivalent of the Chalk Rock, and mark the upper limit of Middle Chalk, attaining a great development at Dover, it became necessary to examine the palæontological position of that bed to which the name "Chalk Rock" was given by Mr. Whitaker. Having studied Mr. Whitaker's description given in the "Geology of the London Basin," and having examined exposures of this rock between Cambridge and the Thames, he came to the conclusion that there was probably more than one bed to which the name Chalk Rock might be applied, and that these, probably not all persistent, may occur at different palæontological horizons. He therefore proposed to take the zone of *H. planus* as the top of the Middle Chalk; although this zone was difficult to identify inland, from the paucity of its fossils, the base of the overlying zone was well marked by the abundance of Micrasters and other forms, which appear to him more closely allied to Upper than to Lower Chalk.

He believed that while the Chalk Rock seen at Henley may be considered the summit of the Middle Chalk, the Chalk Rock of Cambridgeshire, though convenient for marking the summit of the Middle Chalk of that county, included that which was really the upper part of the zone of *H. planus* and the base of the true Upper Chalk, the equivalent of Chalk with many Micrasters of Dover.

He would therefore consider the Middle Chalk of Dover to be that included from the base of the grit-bed to the summit of the zone of *H. planus*. Its thickness was 242 feet at Shakespeare's cliff. He was indebted to M. Curry, Esq., of Dover, for this accurate measurement.

IV.—HIGHBURY MICROSCOPICAL AND SCIENTIFIC SOCIETY.—At a numerously attended meeting of the members of this Society, held on Thursday, the 28th January, at Mr. E. P. Sell's, 63, Highbury Hill, the President, James Smith, Esq., F.L.S., F.R.A.S., moved, and Mr. Fitch seconded, the following resolution:—

> "That the Members of the Highbury Microscopical and Scientific Society having heard with the most sincere regret of the death of their Vice-President, Mr. J. B. Jeaffreson, M.R.C.S., desire to place upon record their deep sense of the loss they have sustained, and to express their appreciation and admiration, not only of his attainments as a scientific man, and the able manner in which he discharged the duties of President, but more especially of his character as a kind and sympathetic friend; and they furthermore desire that the Secretary do, in a suitable manner, convey to Mrs. Jeaffreson and the family the assurance of their heartfelt sympathy with them in their sorrow."

CORRESPONDENCE.

"CONE-IN-CONE."

Sir,—I am glad to observe in the short article on "Cone-in-cone," by Professor Newberry, M.D., in the December Number of the Geological Magazine for 1885, that he at one time was inclined to look upon that structure as due to "the escape of gases through a pasty medium." I think that if he had the opportunity of studying the large series of specimens that I have now assembled, and the transparent sections of the cone structure that I have prepared, he would still be inclined to favour that view as an explanation of the phenomena that they present, rather than the one he now adopts, viz. "an imperfect crystallization" of the deposit in which it is found. Professor Newberry, after referring to a number of cases of cone-in-cone structure that had come under his observation (some of which apparently differ from what I have described), concludes by stating that these examples "seem to me to be incompatible with the theory that cone-in-cone is caused by pressure, or the escape of gases, and appear rather to confirm the conclusion that it is due to an impeded tendency to crystallization." He, however, in the article in question, offers no evidence in support of this crystallization theory, nor does he explain in any way the peculiar structure and arrangement of the cone layers. Those supporting a crystallization theory have not referred to any known law of crystallization, which would account for a structure agreeing with what is seen in the best-preserved specimens of our Scottish cone-in-cone, or which would satisfactorily explain all that is represented in the external structure of the cones, and their terminations on the surface of the bed, as is briefly noted in the short abstract of the paper I read to our Glasgow Geol. Soc., and printed in the June Number of the Geol. Mag. for 1885. In the abstract, to which I would refer your readers, I have endeavoured to indicate what is seen in both the internal and external structure of the cones, but which I explain more fully in my paper, and I do not think that in either I have ventured to hazard any explanation that is not fully warranted by what the specimens reveal.

During the progress of my investigations, I have not wholly relied upon my own judgment in coming to the conclusion that the cone-in-cone structure was due to the escape of gases generated in the sediment, but that from time to time I have had the opportunity of submitting specimens and sections of the structure to Dr. Young, Prof. of Geology; Prof. Sir William Thomson, President of the Glasgow Geol. Soc., and his brother Prof. James Thomson, who has paid some attention to rock structures; likewise to Mr. Ferguson, Prof. of Chemistry in this University, and to others, on whose opinion I could rely, and I am pleased to be able to state, that they are all inclined—so far as the specimens noticed in my paper are concerned—to agree to the explanation I have given as to the probable origin of the structure. They also agree with me in thinking that none of the agencies to which cone-in-cone structure has been usually ascribed—such as crystallization, pressure acting on concretions in the process of formation, or chemical deposition of sediment—will ever explain the points of structure and other characters seen *in the specimens that I have selected for description.*

Hunterian Museum, John Young.
University, Glasgow, *Jan. 5th*, 1886.

ON A NEW PERISSODACTYLE UNGULATE FROM WYOMING.

Sir,—In the Geological Magazine for February, 1886, it is stated, p. 50, that no Perissodactyle mammal was known "to possess tubercular teeth." Professor Cope does not supply the characters to which his term 'tubercular' is applicable. If he would kindly refer to p. 362 of my "Palæontology" (2nd ed. 1861), enlarged views of the molars of both jaws of a genus of Perissodactyles (*Pliolophus*), from Eocene, will be found. A still earlier example of 'tubercular' molars, in the genus *Hyracotherium*, is described and figured in "British Fossil Mammals and Birds," 8vo., 1846, p. 422, cut 166: also from the 'London Clay.'

Permit me to add that my estimate of the claims of Elephants and Mastodonts to rank as an 'Order' rests upon the multilamellate structure, size and succession of their 'grinders,' subordinate to which dental character may be cited a vertebral one, necessitating their special instrument the proboscis. The pentadactyle character is common to *Proboscidia* with many Rodent genera, as well as with the older Eocene members of the Coryphodont family, characterized by Lophiodontoid modifications of the true molars. These teeth afford the truest indications of affinity in the Ungulate series. The diminutive Rhinocerontoid represented by the genus *Hyrax* as little determines by molar characters an ordinal distinction form *Acerotherium* as do the modifications of teeth and limbs in *Bradypus* support an ordinal distinction in the Megatherioid family.

Richard Owen.

THE "ALASKA GLACIER."

Sir,—In reference to the description of the *Great Glacier* in Alaska, in "Nature" (Jan. 28th, 1886), I may draw attention to the letter of Mr. J. Melvin in the same number, which would appear to throw light on the subject of the progressive changes in it. The *ridges* delineated in the diagram of the Glacier as lying between the body of the Ice and the hill-side would seem to be analogous to the *Parallel Roads* in Norway valleys, only they are formed on the flat instead of the slope.

The body of the Glacier seems evidently to have *contracted itself* in consequence of loss of substance by melting underneath, and withdrawn itself by *these decided starts* from the hill-side, and left the ridges as relics of its foundations on the bottom of the valley.

Probably the Glacier ages ago was *quite flat* on the top, and reached across to the top of the morainic slope on the hill-side, and it has since lost great bulk below by *ground melting*, which by overstretching has caused the cracks or *crevasses* on the upper surface by consequence of change of shape from the level to the convex.

The *tunnel*, opening out at the butt of the Glacier on to the sea-beach, has doubtless been the main *outlet* for the *ground melting*, and its arched shape may also be deemed significant of the process of convexity adopted by the contraction of the Glacier from side to side.

The mechanism may be likened to the *curling in of the sides* of a piece of wood or paper when the flat side is exposed to the fire,—and it would be all the greater if the other surface were *damped*, just as the upper surface of the Glacier would be by the rainfall or snowfall of the season. Mr. Melvin's explanation of the formation of the *Parallel Roads* in Norway valleys may therefore be provisionally proposed to be applied to the phenomena of *other Glacier actions*, but there are many of these probably that have not convex roofs, nor ground tunnels like the Alaska Glacier. W. J. Black.

United Service Club, Edinburgh, *February*, 1886.

EDESTUS AND *PELECOPTERUS*, ETC.

Sir,—I observe in your interesting article on the *Edestus Davisii*, in the January Number of the Geological Magazine, that you refer to the genus *Pelecopterus*, Cope, as identical with *Ptychodus*, Agass.; the pectoral spines representing the former being supposed to belong to the animal whose teeth have given origin to the second name.

My studies of these fishes have led me to entertain a different opinion from the above. *Ptychodus*, being a shark, is not likely to have a pectoral arch and fin like that of *Pelecopterus*. Moreover, these pectoral spines have been frequently found associated with the jaws and teeth of the "snout-fishes" of the Kansas Chalk, which have been described under the generic head of *Erisichthe*, Cope. Several species are known (see Bulletin U.S. Geol. Survey Terrs. iii. 1877), and one of them is probably the *Xiphias Dixoni* of Agassiz, from the Chalk of Sussex, England. These genera cannot be referred to any of the existing orders of fishes, on account of the peculiar structure of the pectoral arch. I have therefore placed them in an especial one, the *Actinopteri* (see Proceedings Amer. Assoc. Adv. Science, 1877(78), p. 299). E. D. Cope.

Philadelphia, *Jan.* 26, 1886.

NOTE ON THE ABOVE, BY MR. W. DAVIES, F.G.S.

Professor Cope is, I think, mistaken in assigning *Xiphias Dixoni* to Agassiz. The name first appears in a paper by Dr. Leidy "On *Saurocephalus* and its Allies," in the Trans. Am. Phil. Soc. vol. xi. p. 91, where the name was given to the prolonged ethmoid bone referred by Sir Philip Egerton to *Saurocephalus lanciformis*, as then understood.

In that paper Dr. Leidy proves that the teeth assigned by Agassiz to the *Saurocephalus* of Harlan had no relation to that genus, and he refers the jaws and teeth from the English Chalk to a new genus; under the name of *Protosphyræna*, Leidy. The "rostral" bones described by Sir Philip Egerton, he contended did not belong to

Protosphyræna, but to a species of *Xiphias* to which he gave the trivial name of *X. Dixoni*. Subsequently, Prof. Cope described his genus *Erisichthe*, which certainly embodies both of Leidy's species. I may mention here that the prolonged ethmoids are found in our Chalk, Upper Greensand, and Gault; and here also are found (and in no other deposit) the peculiar fin-rays referred to *Ptychodus* by Agassiz. From this association the inference is natural, that the ethmoids and fins belong to the same species of fish, viz. the *Protosphyræna* of Leidy, *Erisichthe*, Cope. (See paper by W. Davies, F.G.S., on *Saurocephalus lanciformis* of the British Cretaceous Deposits, with description of a new species, GEOL. MAG. 1878, Decade II. Vol. V. p. 254, Pl. VIII.)—W. D.

A MONUMENT TO HORACE-BÉNÉDICT DE SAUSSURE.[1]

(BORN AT GENEVA, 1740; DIED 1799.)

SIR,—Chamounix is preparing to erect a monument in memory of our fellow-citizen H. B. DE SAUSSURE.

This memorial will be placed at the foot of Mont Blanc, whose lofty summit the illustrious savant indefatigably reached, not far distant from the Col du Géant, where, in pursuit of science, he encamped amidst snow and ice for sixteen days. In short, it will adorn the central position from which all the Alpine excursions of this intrepid explorer originated.

It is impossible to enumerate here all the titles acquired by De Saussure in the scientific world. Let us only remember that he was an eminent physician, a distinguished meteorologist, a charming writer, who devoted thirty of the best years of his life to the study of those Alps whose beauties he revealed with precision and poetic feeling, and as a conscientious and indefatigable investigator he became one of the founders of modern geology by placing that science on its true basis—*observation*.

The proposal to raise a monument naturally met with the most sympathetic support when it was presented to the members of the Alpine Clubs of all countries, who met at Chamounix in August, 1883, and at Turin in August, 1885.

Since then an Executive Committee has been formed, composed of Messrs. Folliguet (Mayor of Chamounix), Tairrez Payot, Thévenet, President, and Maillot, Secretary of the Mount Blanc section of the French Alpine Club, soliciting them to assist with their subscriptions the erection of a monument.

Switzerland and Geneva in particular would wish to be associated with the homage rendered to the merits of our eminent citizen. Above all, the people of Geneva ought to be interested in a monument designed to preserve the memory of a man who shed such lustre on our city and our ancient Academy. One knows, in fact, that in spite of his numerous travels and his absorbing scientific studies, he found time during many years to occupy a modest philosophical chair in his native town, where he exhibited all the high qualities of his exalted intellect.

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[1] Among various writings, his most important work is the record of his Alpine observations: "Voyages dans les Alpes," in 4 vols. 1779–96.

It is equally well known that he interested himself all his life in our scientific and literary institutions as well as the intellectual and material development of our ancient Republic. Many of his writings, unknown doubtless elsewhere, were received here, and the Society for the Advancement of Art founded by him still continues a work to which he was devoted.

Even when this monument to his memory shall have been raised on foreign soil, Geneva will show its gratitude towards those who have taken the initiative in this demonstration, and will honour those who take part in it.

It is with this firm assurance that the Committee at Geneva is formed to collect subscriptions.

The inauguration of the memorial is projected for the 3rd of August, 1887, that being the centenary of H. B. de Saussure's ascent of Mont Blanc. There is therefore no time to be lost that it may be finished by that date. It is important that the Initiative Committee at Chamounix should know as soon as possible the sum they have at their disposal, in order to decide what form the monument should take.

ALPHONSE FAVRE,
President of the Swiss
Geological Commission.

6, RUE DES GRANGES, GENEVA,
20th December, 1885.

A MONUMENT FOR PROFESSOR OSWALD HEER OF ZURICH.

SIR,—Two years have passed since Death carried off one of the most eminent naturalists of our age—Oswald Heer. He died on the 27th of September, 1883. The fitting moment seems to have arisen to render Dr. Heer a public acknowledgment and to raise a lasting monument to his memory. We are glad to be able to inform you that a sculptor of Zurich, M. Hörbst, has modelled a bust in clay, which gives the naturalist's expression in the most pleasing manner.

The work of Heer was wide-spread. Although truly Swiss at heart, and studying with delight the primitive history and flora of his native land, his researches extended far beyond the limits of his own country. He had become one of the highest authorities on the domain of vegetable palæontology, and from all parts of the world, from the islands of Sunda and from "hyperborean" lands, from Portugal and Eastern Siberia, from the New World as well as the Old, he gathered materials for his researches, and specimens came for identification. The works of Heer on the fossil flora of the Polar regions have placed him among the foremost ranks as one of the founders of modern botanical geography; for to him, and him alone, is due the merit of having discovered, by studying the marvellous Tertiary flora of Greenland, Spitzbergen, and Arctic America, facts of the utmost importance to science. His name will perpetually remain united with those who have explored Arctic regions, his researches will long form the basis of our knowledge of prehistoric climates.

Feeling assured of the eminently international character of Heer's work, we confidently appeal to all to raise a worthy monument to his memory.

It is proposed that this monument should consist of a marble bust on a stone pedestal, protected in a suitable manner from the inclemencies of the weather, to be placed in the Botanical Gardens at Zurich, on the spot where Heer's energy was so well displayed. The price of the memorial would reach about 5000 francs.

Besides which, the sculptor, M. Hörbst, is prepared to execute, for 150 francs each, plaster casts of the original. If you desire one of these copies, have the goodness to inform us, when sending your contribution. Subscriptions will be gratefully received by Dr. C. Schröter at Hottingen, Zurich. They may be sent direct, or through the medium of the undersigned.

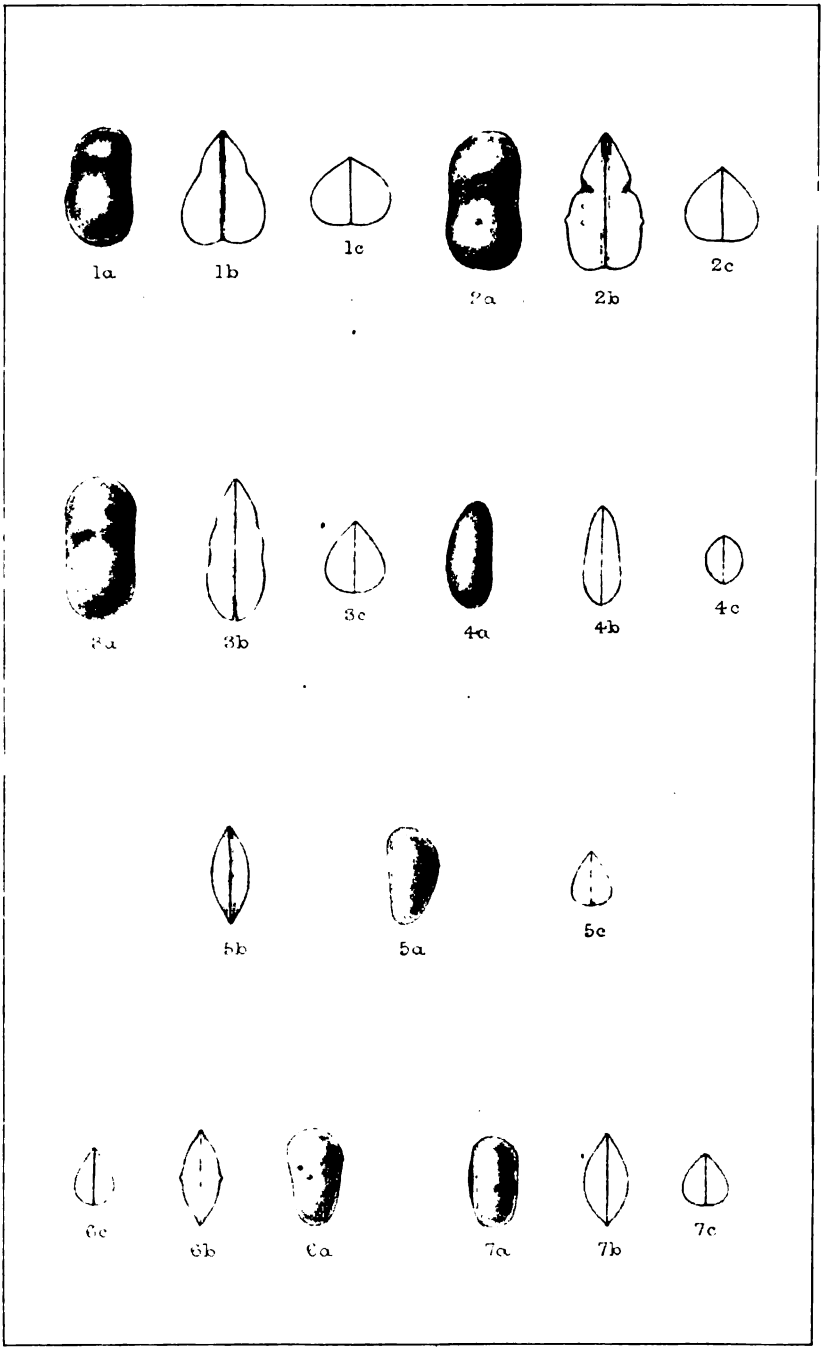
Prof. Dr. A. MOUSSON, Polytechnikum, Zurich.
Prof. Dr. C. CRAMER, „ „

OBITUARY.

PROFESSOR A. VON LASAULX PH.D.

WE deeply regret to have received tidings of the death of this distinguished German Geologist and Mineralogist, which took place at Bonn, on the 25th January last, after a short illness. Dr. Von Lasaulx was only in his 47th year; yet he had been the author of a remarkably large number of Memoirs on petrological subjects, as well as of more solid works, of which, perhaps, the joint work on Etna of Sartorius von Waltershausen and himself is the most splendid example. In 1876 Dr. von Lasaulx, in company with his friend Dr. Ferdinand Roemer, of Breslau, visited the British Isles; and was present at the meeting of the British Association in Glasgow in that year. On his return to Bonn, he published an account of his wanderings, in the form of a handsome book, "Aus Irland, Reiseskizzen und Studien," in which the physical features and geological structure of the districts visited are closely noted and graphically described, together with the mineral characters and composition of many of the rocks as determined under the microscope; of these, the most important was the discovery of tridymite in the trachytic rocks of Antrim (Petrographische skizze aus Irland; mineralogischen und petrographischen Mittheilungen, Wien, 1878, p. 410). The volcanic rocks of Bonn and the neighbourhood afforded a rich field for the petrological investigations of this lamented naturalist, of which he made abundant use. E. H.

We regret to record the death (on the 16th February, from heart-disease) of Mr. W. W. Leighton, who, since the year 1867, has filled the office of Clerk to the Geological Society of London, and has during 19 years been a most faithful and valued servant to the Society.



E. C. Knight del et lith.   West, Newman & Co imp.

Fossil Ostracoda from Colorado.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. IV.—APRIL, 1886.

ORIGINAL ARTICLES.

I.—On Some Fossil Ostracoda from Colorado.

By Prof. T. Rupert Jones, F.R.S., etc.

(PLATE IV.)[1]

IN December last Dr. C. A. White, Palæontologist to the U.S. Geological Survey, sent me a small packet of siliceous Ostracoda, obtained by dissolving in dilute acid some pieces of an impure limestone from the Jurassic "*Atlantosaurus* Beds" near Cañon City, Colorado. These strata are of freshwater origin; and, besides the wonderful Dinosaurian and Mammalian fauna, which Prof. O. C. Marsh has published, they contain, Dr. White informs me, *Unio*, *Limnæa*, *Planorbis*, and *Valvata*, all of modern types. In the impure limestone with Ostracods, and in associated layers, these Gasteropods are found also in a silicified state, and the Dinosaurian fossils occur both above and below them.

In January of this year I received also from the U.S. Geological Survey, through Dr. A. C. White's kind agency, a piece of the hard limestone itself, for the examination of the microzoa not treated with acid. Some fragments, carefully crushed, yielded free specimens, but not so many nor so perfect as those obtained by acid-solution of similar pieces. By careful manipulation my friend Mr. C. D. Sherborn succeeded in finding some that showed traces of ornament by the presence of the whitish matrix (siliceous) in rows of little pits and in slight furrows similar to those on the Purbeck *Metacypris Forbesii*. Consequently these little siliceous organisms are not all internal casts, but some are perfect carapaces.

On the examination of thin sections and decalcified slices, many sections of Ostracodous bivalved carapaces are recognized, also crushed valves and numerous fragments. The test is often apparent, replaced by silica. No limbs nor internal organs are visible within the whole (bivalve) tests; only groups of brown granules, arranged somewhat concentrically, as also in the neighbouring siliceous infillings of *Limnæa*, and other Gasteropods, and in the chalcedonic (agate-like) infillings of rifts and other spaces in the matrix. In some instances the carapace-valves are absent, and the first inside layer of chalcedony imitates the shell. On being decalcified, a slice loses much of its brownness; but some of the silica still retains a brown tint.

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[1] This Plate was drawn with aid of a grant from the Royal Society for the illustration of fossil Ostracoda.

1. METACYPRIS FORBESII, Jones. Plate IV. Figs. 1*a*, 1*b*, 1*c*.

M. Forbesii, Jones, Quart. Journ. Geol. Soc., vol. xli. 1885, p. 345, pl. 8, figs. 11–16 (including var. *verrucosa*); *M. Forbesii*, Jones, in Bullet. U.S. Geol. Surv. February (?), 1886.

Comparing our Figs. 1*a*, 1*b*, 1*c*, of the American *Metacypris* with figs. 13 and 15 of plate 8 referred to above, we see no special difference except that the antero-dorsal (nuchal) constriction is stronger in the former two figures, and the valves are rather more swollen in their posterior moiety.[1] The siliceous specimens figured do not show the ornament seen in their English representatives; but some that have been beaten out (not separated by acid) show the characteristic ornament, as stated above. Not rare.

For the proportions of this and the other species, see the Table at the end.

2. METACYPRIS BRADYI, sp. nov. Pl. IV. Figs. 2*a*, 2*b*, 2*c*.

M. Forbesii [var.], Jones, in Bullet. U.S. Geol. Survey, February (?), 1886.

"This is even longer in proportion than our most oblong form," such as fig. 11, pl. 8, Q.J.G.S. vol. xli.; and the constriction is very strong, being deep, curving forward, and reaching quite across the valve.[2] The posterior moiety of each valve is relatively less swollen than in *M. Forbesii*; but the convexity of the anterior portion is more pronounced, and more markedly defined by the transverse sulcus; and, owing to the curve of the furrow, the hinder portion has an almost round convexity. A pimple on the centre of this part, and some few elsewhere, show an analogy to the warty condition of *M. Forbesii*, var. *verrucosa*, *op. cit.* pl. 8, figs. 12 and 15. Not rare.

I propose to name this, as a distinct species, after my friend Dr. G. S. Brady, F.R.S., who first recognized the genus *Metacypris* (*op. cit.* p. 344).

3. METACYPRIS WHITEI, sp. nov. Pl. IV. Figs. 3*a*, 3*b*, 3*c*.

Metacypris, sp. Jones, in Bullet. U.S. Geol. Survey, February (?), 1886.

"This form is narrow [relatively], oblong, and compressed; and bears a distant resemblance to '*Cypris* (?) *conculcata*,' Jones, Quart. Journ. Geol. Soc., vol. xvi. 1860, p. 266, pl. 16, figs. 3*a* and 3*b*" (3*c*, young?). Valves oblong, nearly straight above and below, almost equally rounded at the ends; compressed in front, thicker behind. Impressed at the anterior third with a shallow sulcus, and with a faint hollow near the anterior hinge. Edge-view narrow-ovate, sharp in front, obtuse behind, and somewhat undulate at the sides by reason of the slight depressions. Not rare.

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[1] Some of the English specimens are more constricted than shown in the figures and descriptions, *op. cit.* p. 345.

[2] The transverse sulcus impressed on or near the mid-dorsal region of each valve is characteristic also of *Limnicythere* and occurs in some other recent Ostracods of estuarine and freshwater habitats, namely, *Cyprideis* (*Cytheridea*), and one *Cypris* (*C. gibba*, Ramdohr).

This species is named after Dr. A. C. White, Palæontologist of the U.S. Geological Survey, Washington, who kindly submitted these interesting Colorado specimens for my examination.

Another fossil *Metacypris* was described and figured some years ago as *Cypris strangulata*, Jones (Quart. Journ. Geol. Soc. vol. xvi. 1860, p. 187, pl. 10, figs. 73*a*, *b*, *c*, *d*, comprising probably two species), from the Tertiary beds of Central India, at Pahádsingha and Butára, both in the Province of Nagpur (*op. cit.* pp. 165, 166).

4. DARWINULA LEGUMINELLA (E. Forbes). Pl. IV. Figs. 4*a*, 4*b*, 4*c*.

D. leguminella (E. Forbes), Jones, Q. J. G. S. vol. xli. 1885, p. 346, pl. 8, figs. 30 and 31; and in Bullet. U. S. Geol. Surv. February (?), 1886.

It is evident that, judging from the shape and size of the carapace, we must refer these American specimens, which are not rare, to the same genus and species as determined for the similar little Purbeck-Wealden Ostracods of England and Hanover.

Darwinula Stevensoni, Brady and Robertson, lives at present in the brackish water of tidal rivers, and has been found fossil in late Tertiary deposits belonging to the Forest-bed series of Suffolk. *D. Berniciana*, Jones (Proceed. Berwicksh. Nat. Club, 1884, vol. x. p. 325), is a Lower-Carboniferous form in Northumberland, and *D.? pungens*, J. and K., occurs in the Coal-measures of Scotland. Another probable *Darwinula* is the *Cypris* (?) *Allportiana*, Jones, from the Neocomian[1] freshwater beds near Bahia, in Brazil; see Q. J. G. S. 1860, vol. xvi. p. 267, pl. 16, fig. 16.

5. CYPRIS PURBECKENSIS, E. Forbes. Pl. IV. Figs. 5*a*, 5*b*, 5*c*.

Cypris Purbeckensis, E. Forbes. Jones, Q. J. G. S. 1885, vol. xli. p. 347, pl. 9, figs. 1–6.

The figured carapace, Fig. 5*a*, corresponds with fig. 5, in pl. 9, Q. J. G. S.; and Fig. 5*b* nearly with fig. 4 of that plate, in which various forms of this species are given. It is common in the English Purbeck beds, but rare and smaller in the sample from Colorado.

6. CYTHERIDEIS MARSHII, sp. nov. Pl. IV. Fig. 6*a*, 6*b*, 6*c*.

This carapace, apparently perfect (showing the translucent edges of the closed valves), approaches very near to *Cytherideis trigonalis*, Jones, Monogr. Tertiary Entom., Pal. Soc. 1856, p. 47, pl. 2, figs. 2*a*–2*h*; but the curve and slope of the front margin differ, this end being slightly blunter in the American form. The greatest convexity, also, is rather ventral than along the middle. Rare.

This species is named after the eminent palæontologist who has worked so enthusiastically and successfully in these highly interesting fossiliferous deposits of the Far West.

7. CYTHERIDEA? ATLANTOSAURICA, sp. nov. Pl. IV. Figs. 7*a*, 7*b*, 7*c*.

An oblong, convex carapace, round-ended, with the anterior rather higher (broader) than the other end, and slightly oblique. Valves somewhat undulate, being faintly impressed in the postero-dorsal region. The convexity is greatest along the ventral region, causing this part to swell out a little beyond the ventral margin. Edge view oval with sharp ends; end view short-ovate, acute above, broad below. Rare.

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[1] Referred to the Neocomian by Dr. A. C. White in a work prepared by him for publication by the Brazilian Government.

This distantly resembles the smooth variety of *Cytheridea torosa* (Jones), Monogr. Tert. Entom. 1856, p. 21, pl. 2, fig. 1*e*; var. *teres*, Brady (Trans. Linn. Soc. 1868, vol. xxvi. p. 425, pl. 28, figs. 7–12; Ann. Mag. Nat. Hist. 1870, ser. 4, vol. vi. pp. 21, 22, *note*; Monogr. Post-Tert. Entom., Pal. Soc. 1874, p. 178, pl. 7, figs. 1 & 2). The anterior hinge, however, is more definite, though not prominent, the shape is rather more truly oblong, and the sub-medial impression is not so strong. As I have not seen an interior of a valve, I cannot say if this American species belongs to *Cytheridea* or to *Cytherideis*.

TABLE OF PROPORTIONS.

	Length.	Height.	Thickness.
Metacypris Forbesii, Fig. 1	15	9	11
M. Bradyi, Fig. 2	18	10	10
M. Whitei, Fig. 3	18	9	8
Darwinula leguminella, Fig. 4	14	6	5
Cypris Purbeckensis, Fig. 5	13	6	5
Cytherideis Marshii, Fig. 6	13	7	5
Cytheridea ? atlantosaurica, Fig. 7	12	6	6

If these proportional numbers be divided by 15, the result will be linear dimensions in a millimètre and parts of a millimètre; the figures being magnified 15 diameters.

As the anterior extremity is placed upwards in the figures, the *height* of the valves appears as *width* on the plate.

The species Figs. 1, 2, 3, 4 are abundant; those shown by Figs. 5, 6, and 7 are rare.

EXPLANATION OF PLATE IV.

(The figures are magnified 15 diam.)

Throughout *a* is the side view; *b*, edge view; *c*, end view of the bivalved carapace.

FIG. 1. *Metacypris Forbesii*, Jones; *a*, right valve outwards.
,, 2. *M. Bradyi*, Jones; *a*, right valve outwards.
,, 3. *M. Whitei*, Jones; *a*, left valve, outwards.
,, 4. *Darwinula leguminella* (E. Forbes); *a*, right valve outwards.
,, 5. *Cypris Purbeckensis*, E. Forbes; *a*, left valve outwards.
,, 6. *Cytherideis Marshii*, Jones; *a*, left valve outwards.
,, 7. *Cytheridea ? atlantosaurica*, Jones; *a*, left valve outwards.

II.—NOTES ON A COLLECTION OF FOSSIL FISH-REMAINS FROM THE MOUNTAIN LIMESTONE OF DERBYSHIRE.

By JAMES W. DAVIS, F.G.S.

I AM indebted to Thos. Parker, Esq., of Oldham, for the opportunity he has afforded me of examining his large collection of fish-remains from the Carboniferous Limestone of Derbyshire. The specimens have been obtained from quarries near Chapel-en-le-Frith, in the N.W. of the county. They are for the most part in a beautiful state of preservation, though some of the more fragile specimens are only obtained with the most careful manipulation on account of their liability to fracture. The fossils are creamy-white in a light-coloured crystalline limestone matrix.

The fauna of this district affords some features of peculiar interest. There is an entire absence of fin-rays, and of the sharply-pointed conical teeth like *Cladodus*, a negative evidence of their intimate relationship where present. There are two genera of Petalodontidæ, three of the Copodontidæ, five of the Cochliodontidæ, one of *Pleurodus* and one of *Psammodus*. Of all these only one species, *Psephodus magnus*, Agass., has been previously recorded from Derbyshire. Besides *P. magnus*, the following fish-remains have been chronicled either in M'Coy's British Palæozoic Fossils, or in the Fossil Fishes of the Carboniferous Limestone series of Great Britain, in the Transactions of the Royal Dublin Society, by the present writer:—

Acondylacanthus (*Leptacanthus*, M'Coy) *junceus*, M'Coy.
Cladodus mirabilis, Agass.
Cladodus striatus, Agass.
Pristicladodus dentatus, M'Coy.
Petrodus patelliformis, M'Coy.
Deltodus aliformis, Agass.
Deltoptychius acutus, Agass.
Pœcilodus foveolatus, M'Coy.
Petalodus acuminatus, Agass.
Cheirodus pes-ranæ, M'Coy.

To this list is now added twelve species, five of which have not previously been described; they are comprised in the following descriptions, to which are added such observations as appear necessary to indicate peculiarities of form or structure.

Family PETALODONTIDÆ, Newberry and Worthen.

Genus *Petalodus*, Owen.

Owen, Odontography, p. 61 (1840).
Davis, Trans. Roy. Dublin Soc., n.s. vol. i. p. 429 (1883).

Petalodus Hastingsiæ, Owen.

Odontography, p. 61, pl. xxii. figs. 3, 4, 5.
Davis, *l.c.* p. 493, pl. lix. figs. 16–21.

A considerable number of the teeth of this species have been found varying in size as well as in form. An average tooth apparently of full size is 0·35 inch across the crown; the height of the latter being 0·15 inch. The base is nearly double the height of the crown. Whilst agreeing generally in form with the species from the Mountain Limestone of Armagh, it differs in the greater area occupied by the imbricating ridges at the base of the crown; whilst the former possess five or six folds or ridges, the specimens from Derbyshire have nine. Some of the examples are broader across the crown, than the average tooth already named, and the height of the crown is less, very thin, and almost straight. This may be due to greater wear, the coronal surface being reduced from the normal convexity to a more or less straight edge; or, it may indicate a different species. The broad form closely resembles in some particulars the specimens of *Petalodus inequilateralis* from the Limestone of Wensleydale.

Genus *Petalorhynchus*, Agass. MS.

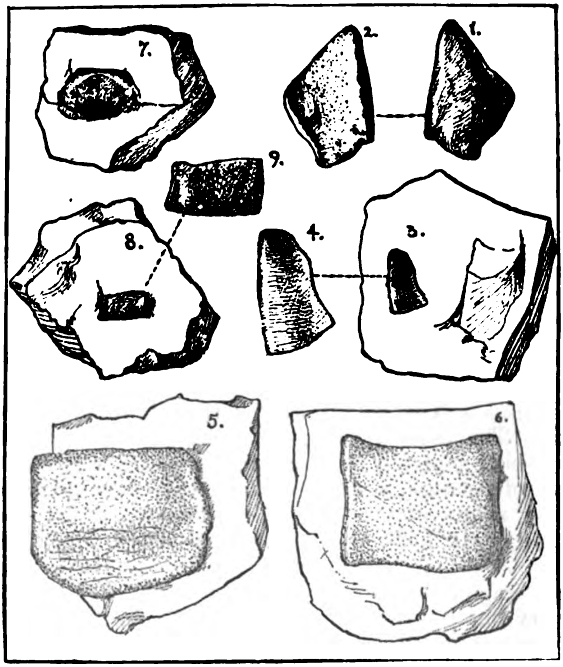
Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 516 (1883).

Petalorhynchus psittacinus, Agass. MS.

Davis, *l.c.* p. 516, pl. lxi. figs. 12–16.

Hitherto the teeth of this species have been found only in the Mountain Limestone at Armagh and the Carboniferous Series near

Glasgow. The specimens from Derbyshire present as great a variety in form as those from Armagh so far as the series extend, and there can be little doubt that the species is the same. In one or two of the best-preserved examples, the depth of the tooth only exceeds the breadth by one-fifth, and consequently is probably from the posterior part of the mouth; the sigmoidally curved folds of the ganoine, extending across the external surface at the base of the crown, are only three in number. In the species found at Armagh there are four or five imbricating folds. The beak-like cutting-edge of the crown is somewhat deeply and broadly serrated along each lateral margin in some of the specimens; in this it also diverges from the types and offers a superficial resemblance to the teeth of the genus *Ctenopetalus.* Minute vertical furrows extend from the cutting margin downwards over the anterior surface of the crown.



Palatal Teeth of Fishes from the Carboniferous Limestone, Chapel-en-le-Frith, Derbyshire. Coll. Thos. Parker, Esq.

Family COCHLIODONTIDÆ, R. Owen.

Streblodus oblongus, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 424, pl. liii. figs. 1–4 (1883).

Remains of the teeth of this species are not uncommon. They are usually detached, and owing to their extreme brittleness, and the difficulty with which they are developed from the matrix, they are often fragmentary. An example exhibiting the series of three teeth covering a ramus of the jaw has not yet been discovered. The large posterior teeth are most commonly met with. They are much smaller in size than those of the same species from the Mountain Limestone of Armagh, generally about 0·5 inch in length and 0·3 in breadth. They possess the characteristic convolution of the genus. The enamelled surface of the crown is exquisitely and perfectly preserved, and in most instances does not exhibit much trace of being worn by attrition, from which it may perhaps be reasonably inferred that they are the teeth of a young individual.

Genus *Psephodus*, Agass, MS.

Davis, Trans. Roy. Dub. Soc. n.s. vol. i. p. 438 (1883).

Psephodus magnus, Ag.

Trans. of the Royal Dublin Society, ser. ii. vol. i. p. 439, pl. lv. fig. 1–14.

Several examples of this species have been found. They do not materially differ from the specimens described from the Carboniferous Limestone of Armagh. The largest tooth, probably occupying a median position on the jaw, is 0·85 inch in greatest diameter, more or less pentagonal in outline, the upper surface highly convex, and the under one correspondingly concave.

A second specimen consists of two teeth joined together similarly to those represented in the memoir named above, pl. lv. fig. 4, the two upper and larger teeth; the Derbyshire ones are about two-thirds the size of those from Armagh.

Teeth occur which differ from the types in some particulars. They are almost circular in form, and equally convex from all sides; their diameter across the crown is slightly less than half an inch. They may represent a different species of this genus of fossil fishes, but until a larger number of specimens have been found affording more complete evidence of its peculiar characters, it appears advisable to retain them under the above title as a variety of the old type.

A number of small helodont teeth are scattered over some of the pieces of limestone. They are small and elongated, smooth and even on the surface of the crown, without median or other prominence. They were probably connected with this or the following species of *Psephodus.*

Psephodus simplex, Davis, sp. nov. (Figs. 1, 2, p. 150).

Teeth trapezoidal in outline, longest diameter 0·8 inch. Two longest sides forming an acute angle at the apex. The two shorter ones, half the length of the longer, inclosing an obtuse angle. The surface of the crown is convex (Fig. 1), its enamelled surface covered with small punctures. The margins of the tooth are thick. The under surface (Fig. 2) forms a channel extending parallel with the long axis of the tooth, which like the under side of *Psephodus magnus*, Ag., was attached to one of the cartilaginous jaws of the fish.

The teeth comprised in this species, of which several specimens have been found, are almost identical in shape. They differ from those of *P. magnus* in form; the latter are more or less pentagonal or rounded, whilst this species is four-sided, two being so much longer than the others as to assume almost a triangular appearance. I have ventured to distinguish the species by giving it the name *Psephodus simplex*.

Genus *Deltoptychius*, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 432 (1883).

Deltoptychius plicatus, Davis.

Quart. Journ. Geol. Soc. vol. xl. p. 628, pl. xxvi. figs. 13, 14 (1884).

Several teeth of this species have been obtained. They do not materially differ from those described in the paper referred to above, from the Yoredale Series of Wensleydale, in the possession of Mr. Horne; like them, they are readily distinguished from the type species of Agassiz, *D. acutus*, by the greater prominence of the ridges occupying the surface of the crown; the more regular and broader form; and more widely expanded outer margin. The Derbyshire specimens are slightly larger than those found at Wensleydale. They are delicately and beautifully punctate on the surface.

Genus *Pœcilodus*, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 441 (1883).

Pœcilodus Jonesii, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 442, pl. liii. fig. 20-23.

Teeth of this genus have been found. They correspond with those of the same species found at Armagh in essential characters. They are of two forms, the larger posterior tooth is about 0·5 inch in breadth, the length equalling half the breadth. The posterior portion of the tooth is broadest and is free from ridges. Its surface is considerably worn and forms a concave depression. The remainder of the crown is traversed by 7 or 8 parallel ridges. The whole is enamelled and punctate. The *second tooth* is smaller, sub-triangular in outline; its length is the same as that of the larger tooth, 0·25 inch; the greatest breadth is 0·1 in., diminishing towards the opposite extremity. Five ridges are exposed, extending transversely across the surface, separated by somewhat deep grooves. It is similarly enamelled and punctate to the posterior tooth.

The only species of the genus *Pœcilodus* hitherto recorded from the Mountain Limestone of Derbyshire is *P. foveolatus*, M'Coy (British Palæozoic Fossils, p. 639, pl. 3G). The type is in the Woodwardian Museum, Cambridge, and is unique. It is readily distinguished from the specimens in Mr. Parker's collection by its large size, narrow, elongate form, more numerous and diagonally disposed ridges, and the regular rows of puncta which run parallel with the ridges. The species, *Pœcilodus Jonesii*, named by the late Prof. Agassiz, and described in the memoir cited above, has hitherto been found only in the Limestone of Ireland. It comprises teeth of two forms originally considered by Agassiz to represent two species, but proved by specimens in the collection of the Earl of Enniskillen, now transferred to the Natural History Museum, Cromwell Road, to belong to the same species, and to be the anterior tooth of *P. Jonesii.* In this, as in others of its principal features, the species from Derbyshire agrees; and whilst in one or two minor points it is dissimilar—as, for instance, in the greater expansion of the smooth posterior part of the larger tooth, and the fewer number of the ridges on the small one—there can be no hesitation in considering those differences as not more than varietal, and including it in the same species with the examples from Armagh.

Genus *Xystrodus*, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 447 (1883).

Xystrodus Parkeri, Davis, sp. nov. (Figs. 3 and 4, p. 150).

Several exquisitely beautiful little teeth have been found belonging to this genus. They are 0·3 to 0·4 inch in length, and 0·15 to 0·2 inch in width, sub-triangular in outline, rounded anteriorly, and expanding towards the posterior margin. Surface of the crown concavo-convex, rising on one side in the form of a ridge, depressed along the opposite one, forming a broad concave channel extending the whole of the length of the tooth, and expanding into a somewhat aliform margin, more or less sinuous in outline. The surface is enamelled, and a number of minute punctures, arranged so as to form a series of sinuously parallel ridges, extend across the tooth.

This species resembles most nearly that of *Xystrodus pulchellus*, Davis (Trans. R. Dublin Soc. n.s. vol. i. p. 450, pl. lv. fig. 24), from the Yoredale Series of Wensleydale, but may be readily distinguished by its rounded anterior extremity, less acutely triangular form, and the aliform character of the concave margin. The convex margin is rounded in this species, in *X. pulchellus* it is straight.

Xystrodus simplex, St. J. and W. (Geol. Survey of Illinois, vol. vii. p. 178, pl. viii. figs. 4, 5, 1883), is a larger tooth than the one now described, but is similar in form. It may be distinguished by the more acute angle formed by the lateral margins and its point of inrolment being more distinctly developed. The punctæ on the surface are without arrangement into ridges. Messrs. St. John and Worthen consider that the genus *Xystrodus* is closely allied if not identical with that of *Tomodus*, Agass. They remark, "While we have not the data necessary for carrying the comparisons to a final conclusion, we are much impressed by the intimate resemblances which subsist between the present genus and *Tomodus*, Agass. A series of careful sketches of authentic examples of *Tomodus convexus*, Agass., from the Mountain Limestone of Bristol, England, and which were kindly submitted to us by Lord Enniskillen, show this relationship in a striking manner. The genus *Tomodus*, indeed, appears to be a *Xystrodus* in all save the arrangement of the punctæ in parallel transverse lines; and in the latter respect we find a close, though not absolute agreement, in the initial species occurring in the American Carboniferous species *X. simplex*" (*op. cit.* p. 177). It was in 1859 that the late Professor Agassiz, whilst visiting the Earl of Enniskillen, took the opportunity to examine and arrange the magnificent collection of Carboniferous Limestone fish-remains which were then located in the Florence Court Museum. Amongst others, the large, thick, massive, triangular and convolute teeth from Bristol. They are one and a quarter inch in length and nearly half an inch in thickness; the surface, convex from back to front, as well from side to side, almost globose. These were named *Tomodus convexus*. The type specimens are figured in the Trans. Roy. Dublin Society (n.s. vol. i. pl. lv. figs. 15–18). The teeth assigned to the genus *Xystrodus* are medium or small in size, of a triangular form, much elongated, slightly convoluted, and more or less acutely pointed anteriorly. The crown does not present the bold convexity characteristic of *Tomodus*, but is comparatively flat, one side of the crown being raised, the other depressed. *Xystrodus striatus* and *X. angustus*, the Agassizian types, are also figured in the memoir cited above (pls. lv. figs. 7–10 and pl. lv. figs. 19–21). The former was described by Prof. M'Coy under the name *Cochliodus striatus* (Brit. Palæozoic Fossils, p. 624, pl. 31, fig. 27). The group described by Messrs. St. John and Worthen, of which *Xystrodus simplex*, already mentioned, may be taken as the type, have all the characters of that genus, and appear to be closely related to the British species; but there is no evidence with which the writer is acquainted which demonstrates that either the British or American representatives of the genus are generically related to *Tomodus*.

In recognition of the services rendered to palæontological science by Mr. Parker, I have ventured to distinguish this species by appending to it his name.

Family Copodontidæ, Davis.

Genus *Mylacodus*, Agass.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 480 (1883).

Mylacodus variabilis, Davis, sp. nov. (Figs. 5, 6, p. 150).

Teeth trapeziform, length 0·7 inch, breadth 0·9 inch. Crown of at least two different forms, in each the surface is more or less level, slightly convex in central part between the sides, with a sigmoidal curvature in the opposite direction, the posterior and lateral margins are a little raised, inclosing a shallow depression, enamelled, and covered with minute, and in some cases scarcely distinguishable, pustulations. Anterior margin of first tooth straight, laterally more or less straight, slightly diverging to the rounded posterior margin. Angles rounded. *Second tooth*, anterior margin concave; may have been attached to the posterior margin of the first; antero-lateral angles acute, not rounded; lateral margins straight or slightly concave, posterior margin slightly convex, postero-lateral angles slightly rounded. Base not well exposed, mostly hidden in the matrix. Part exposed 0·15 inch in thickness, porous, thinning out towards the margin of the crown, with the upper surface of which it forms an acute angle.

Two species of *Mylacodus* have been described in the Trans. of the Royal Dublin Society, both from the Carboniferous Limestone of Armagh, in Ireland; the types are in the Enniskillen Collection at the new Natural History Museum. From *M. quadratus*, Agass., this species may be distinguished by its greater breadth, straight anterior, and rounded posterior margins. The second tooth is readily distinguished by its form; and both are less distinctly punctate than in *M. quadratus*. The coronal surface of *Mylacodus sesamini*, Agass., is uniformly rugose, and the lateral depressions near the margin are deeper and more extensive. The form of the crown is that of a truncated cone as compared with the broad expansion of the species now described, which it is proposed to distinguish as *Mylacodus variabilis*.

Genus RHYMODUS, Agass. MS.

Davis, Trans. Roy. Dublin Society, n.s. vol. i. p. 473.

Rhymodus convexus, Davis, sp. nov. (Fig. 7, p. 150).

Teeth: length 0·25 inch, breadth 0·45 inch. Crown, median portion uniformly convex, with depression on each side, lateral extremities raised into prominent ridges; surface enamelled; central part considerably worn by attrition, beautifully punctate, without definite arrangement. Anterior and posterior margins similar; central part rounded, with a depression, corresponding to the one across the surface, on each side. Antero-lateral angles produced, slightly rounded; opposite ones similar. Base not exposed.

This species differs from *Rhymodus transversus*, Agass., and *Rhymodus oblongus*, Davis, in the form of the coronal surface. In each of the species named there is a decided concavity in the median part of the anterior margin. In this species the anterior margin is convex. The aliform processes of the crown as well as the root, which are prominent in the two forms previously described, are not largely developed in this species. Whilst differing in specific details from the forms of *Rhymodus*, the transversely oblong form, prominent convex crown with lateral depressions and raised margins, are generic characters sufficiently distinct to leave no doubt as to its relationship with that genus. Having reference to its especially rotund coronal surface, the name *Rhymodus convexus* is suggested to distinguish the species.

Genus *Characodus*, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 474.

Characodus minimus, Davis, sp. nov. (Fig. 8, p. 150).

Teeth trapezoidal in outline, small size; anterior margin 0·2 inch in length, posterior one 0·25 inch; length 0·12 inch. Crown from front to back convex; laterally, slightly convex, the middle portion worn by attrition and somewhat depressed. The surface is covered with enamel, and minutely punctate where unworn. All the margins are straight. The base is hidden by the matrix, but appears to be the same size as the crown.

This tooth approaches most nearly to the generic characters possessed by the genus *Characodus*; it differs from the species hitherto described as *C. angulatus*, Ag., and *C. cuneatus*, Ag. (Fossil Fishes of the Carb. Limestone Series of Great Britain, Trans. Royal

Dublin Society, ser. ii. vol. i. p. 475, pl. lviii. figs. 19, 20, and 21), in the absence of a prominent lateral border on each side of the coronal surface. In the place of this the borders are more or less depressed, except midway between the anterior and posterior angles, where a minute projection forms an angular prominence. This species in its form appears to hold an intermediate position between the two named above; whilst its margin and angles are equally regular with those of *C. cuneatus*, it possesses the elongated form of *C. angulatus*.

Family PSAMMODONTIDÆ, L. G. de Koninck.

Genus *Psammodus*, Agass.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 459 (1883).

Psammodus rugosus, Agass.

Poissons Fossiles, vol. iii. p. 111, pl. xii. figs. 14-18; pl. xix. fig. 15 (1833).

Several teeth of this species have been found: they do not differ from those of other localities, examples of large size are not uncommon. A specimen, of which only a portion is preserved, is 1·1 inch in breadth, a portion of the length only remains. It differs from the ordinary form in the sigmoidal curvature of the surface of the crown from back to front, one portion being depressed and concave, whilst the other is broadly convex, the latter much worn by attrition. The margin of the convex side forms an acute angle with the under surface of the base.

Genus *Pleurodus*, Agass. MS.

Davis, Trans. Roy. Dublin Soc. n.s. vol. i. p. 458 (1883).

Pleurodus Woodi, Davis.

Davis, *l.c.* p. 458, pl. lix. figs. 12–15.

About a score of teeth of this species have been found. They are extremely interesting because they extend the vertical distribution of the genus downwards from the Yoredale beds of Wensleydale to the thick-bedded Lower Limestone of Derbyshire. The type-species, *P. affinis*, was obtained from the Coal-measures, and named, but not described, by M. Louis Agassiz. The same author also named a second species, *P. Rankinii*, from the Coal-shales of Northumberland. In 1870 a specimen was discovered at Newsham, near Newcastle-on-Tyne, which was described by Messrs. Hancock and Atthey in the Trans. of Northumberland and Durham, vol. iv. pt. ii. p. 408, pl. xv. So much of the fish was preserved that its form could be identified. The length of the head and body was 3 inches, the breadth across the thorax 2 inches. The body was covered with mosaic-like tubercles, the tail was not preserved; a spine was inserted immediately behind the thorax, five-eighths of an inch in length, laterally compressed, straight, broad at the base, tapering rapidly to a point. The mouth was large, and there were apparently three or four teeth on each ramus of the jaws. The bones were cartilaginous throughout.

The teeth of *Pleurodus Woodi* indicate a fish about double the size of the one from the Newsham Coal-shales; and, judging from a comparison of the size of the teeth, about half the size of the *Pleurodus affinis*, Agass., also from the Coal-measures. The teeth may be distinguished by the deep transverse ridges and the absence of widely expanded lateral margins, as well as their elongate form. The specimens described in the Transactions of the Royal Dublin Society from the collection of the late Mr. Wood, of Richmond, were tabulated as having been found in the Mountain Limestone of Richmond, in Yorkshire. I have since found that they were from the Upper Yoredale beds near Leyburn, the same locality from whence the collection of Mr. Horne was obtained; consequently Mr. Parker's specimens from Derbyshire are the only ones which have been found in the Lower Limestone. An example of the spine of the fish has not been found; the teeth do not differ in any appreciable degree from the types, and they are probably the same species.

INSERTÆ SEDIS.

A large number of small palatal teeth have been found associated with those already described. They are of varied forms, usually more or less elongated, sometimes of uniform width and even and smooth on the surface; in others, the median portion is raised and gibbous, the lateral extremities depressed and attenuated in width. The under-surface is devoid of basal or root-like extension, and is frequently more or less concave, thus conforming to the convexity of the crown. They are enamelled and covered with pustulations or punctations where the surface has been worn.

Many of these small teeth are probably immature examples of species already described; others may have been associated with them in different portions of the jaws, whilst it is possible that some may be distinct and independent species. It is considered advisable for the present to await the advent of other examples which shall render the determination of their affinities and relationships somewhat less problematical.

III.—ON THE OCCURRENCE OF UNDISTURBED SPOTS IN EARTHQUAKE-SHAKEN AREAS.[1]

By CHARLES DAVISON, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

ONE of the most important discoveries in Seismology is that which proved the close connexion in position between earthquake-centres and lines of fault, leading up to the view that the earthquake is an effect and not a cause of fault-formation. It may be the momentary result either (1) of the sudden fracturing of the earth's crust, or (2) of the impulsive friction that must accompany the relative displacement of the rock-masses adjoining the fissure. Now, earthquakes are frequent at places where faults are already advanced in the process of formation. They also recur continually at one and the same place along a line of fault, the number felt in any area being often greatly in excess of the number of faults beneath that area. Hence, it follows that the majority of non-volcanic earthquakes must be due rather to the individual slips which are the elements of a great displacement than to the repeated fissuring of the earth's crust. On this view, then, the earthquake is but an incident in terrestrial evolution, and has no further connexion with the formation of mountain-chains and continents than the creaking of an unoiled wheel with the motion of a railway train.

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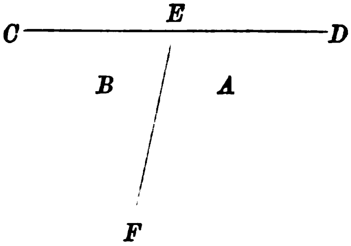
[1] A note read before the Birmingham Philosophical Society on March 11, 1886.

First, let us take the case of an earth-crust homogeneous and of equal elasticity in all directions. Let *E F* represent a section of a fault or fissure, and *C D* the surface of the earth, and let us call the rock-masses on either side the fissure *A* and *B*. Now suppose *B* to be slightly, but suddenly, lowered relatively to *A*. Then the particles of *A* at the surface of the fissure will by impulsive friction be drawn sharply downwards. Similarly, those of *B* at the surface of the fissure will be drawn upwards. Hence, the earth-waves in the two rock-masses will start in opposite phases of vibration. At a distance from the fault this difference will not much affect the character of the earthquake-motion; but along the line of fault, every particle, being urged upwards and downwards equally, will remain at rest; and in the immediate neighbourhood of the line of fault, or its continuation, the disturbance will be less violent than it otherwise would be, owing to partial interference by the spreading of either earth-wave in the adjoining rock-mass.



Returning to the case of the earth-crust as it actually is, heterogeneous and discontinuous in all directions, we find the problem somewhat less simple. We have here to guide us the numerous observations of earthquakes in Japan and other places, and, to a certain extent, the seismic experiments of Prof. Milne and Mr. Gray. These lead us to infer that absolute rest along a line of fault must be a most improbable occurrence, owing to the great irregularity of the surface rocks. Still, we may believe that, in many earthquakes, the disturbances will be less violent along, and in the neighbourhood of, the line of fault, than in other parts of the disturbed area; and that in earthquakes of moderate intensity, the motion may be so slight as to be imperceptible to observers unpractised or without instrumental assistance. Evidently, also, the further away a place is from the spot where the fault-slip occurs, the less likely will it be for the earthquake-waves to interfere there.

The Scottish earthquake of November 28, 1880, furnishes a good example of these considerations. It occurred at 5·40 P.M., after the hour of sunset, and therefore at a time when all the lighthouse-keepers must have been on watch. Mr. C. A. Stevenson, who has studied this earthquake,[1] mainly from the reports of lighthouse-keepers, shows that its epicentrum was in the neighbourhood of the island and lighthouse of Phladda, and therefore at a place on or close to the great fault which traverses Scotland in a south-westerly direction from Inverness. In all probability, the shock was caused by a slip of this fault, some distance below Phladda. On the map illustrating Mr. Stevenson's paper are marked, not only the places where the shock was distinctly felt, but also those where it is expressly stated that no shock or tremor was observed. A glance at this map suffices to show that, along the line of fault, no shock was noticed at the five places nearest the epicentrum, while at two more distant places in Scotland, and again, in the opposite direction on the coast of Ireland, the earthquake was distinctly felt.[2]

In the same manner, the following well-known instances may perhaps be accounted for, though the facts are too few to admit of circumstantial proof[3]—the sparing of a solitary house at Radicina during the Calabrian earthquake of 1783, while the rest of the town was entirely levelled; the phenomenon described by Humboldt, when the earthquake is said by the Andean natives to "form a bridge," being felt in two near but separated areas, and hardly at all in that between; and, lastly, a somewhat similar instance mentioned by Darwin as occurring during the Concepcion earthquake of 1835.

IV.—On the Waterworks at Goldstone Bottom, Brighton.

By W. Whitaker, B.A., F.G.S., Assoc. Inst. C.E.

Communicated by permission of the Director-General of the Geological Survey.

THESE works were at first only supplementary to the Lewes Road Works, on the east; but now are the chief source of supply. They were begun in 1865, and are placed in a hollow in the Chalk, in open ground at the north-western edge of Brighton. This hollow, the bottom of which, I am told, is 30 feet below the lowest part of its rim, is perhaps in itself an evidence of the existence of underground water, being due, most likely, as is usually the case in limestone-districts, to the dissolving away of the rock by underground water and to the consequent sinking-in of the surface. It is an analogous occurrence to the Meres of Norfolk, except that these are generally more or less filled with water, whilst Goldstone Bottom is quite dry at the surface. I may mention that at the time of my visit there was so thick a fog that it was impossible to see the hollow.

The Brighton Waterworks are perhaps the best example of the method to be employed in getting a very large supply from the

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[1] "The Earthquake of 28th November, 1880, in Scotland and Ireland," Edinburgh Roy. Soc. Proc., vol. xi. pp. 176–187.

[2] It should be mentioned that at two other places near Phladda, and not on the line of fault, the earthquake passed unnoticed.

[3] Dolomieu, "A dissertation on the Earthquakes in Calabria Ultra, which happened in the year 1783," Pinkerton's Voyages and Travels, vol. v. p. 290.—Humboldt's Personal Narrative, vol. iv. p. 21.—C. Darwin, "On the Connexion of certain Volcanic Phenomena in South America, etc.," Geol. Trans. second series, vol. v. pp. 605–6.

Chalk, and I was therefore glad to be able to accept the invitation of the Chairman of the Waterworks Committees and of the Engineer, Mr. Edward Easton, to visit the Goldstone Bottom Station on December 6th, 1884, when, under circumstances not likely to occur again for some time, the party, of which I was one, was able to go down into the actual source of supply and to examine it thoroughly.

For the history, engineering details, and general account of the waterworks, the reader is referred to the papers by Mr. Easton in the Report of the British Association for 1872, pp. 395—400, and in the Transactions of the Brighton Health Congress, 1881, pp. 48–56, with three plates.

At Brighton the water is got from the Upper Chalk by sinking shafts down to about low-water-level, and by then driving galleries, or small tunnels, more less at right angles to the dip of the beds, so as to cut the fissures along which water flows in its passage from the higher ground on the north to the sea. The present supply is plentiful; but the Corporation have looked well ahead, and took advantage of a late dry season, to extend these tunnels and so to get a future increase (at the Goldstone Works).

The depth of the shafts varies of course as the level of their sites. At Goldstone Bottom there are four, and their depth is 150 feet and more. The tunnels vary somewhat in size, up to a height of 18 feet and a width of 12 feet. Under ordinary circumstances these tunnels are filled with water; but, in order to extend them, they were practically pumped dry (except for small channels by the side), and about 2,000,000 gallons of water were run to waste daily, after enough had been taken for the supply of the town and neighbourhood. By the skilful management of the resident engineer, Mr. Baker, the chalky water, that comes from the parts where work was going on, was kept separate from the ordinarily clear water of the springs cut; so that the supply was still got whilst the work went on.

The tunnels are in white chalk, with but few flints in the flat planes of bedding; but with many oblique layers of thin flint filling joint-planes. These, it should be remarked, are evidence of water-flow, having probably been formed by slow deposit from water along the joints. Some joint-fissures on the other hand are filled with a soft calcareous and sandy deposit, the sand brought down from above by the sinking water. Though some of the chalk seemed fairly soft, yet I am told by Mr. Easton, that much of it was found to be very hard, needing, almost constantly, chisels and sledge-hammers to break it, picks being often of no use.

At Goldstone Bottom the length of the tunnel was 1800 feet in 1881, to which there had since been added (or would be added by the work in progress) 2600 feet.

The supply comes chiefly from three or four springs yielding from 4000 to 5000 gallons a minute, a long way apart. Though there are many small additions between these, yet it is noteworthy how far, in these works, a tunnel has been driven before cutting a fissure yielding a large supply, as this points to the need, in some cases, of great lateral extension to get the required supply from the Chalk.

Had recourse been made to boring, or even to a shaft, only, failure would almost certainly have ensued, where now the most successful result has followed from driving galleries. At the Lewes Road Works a different state of things occurs: the springs are very much smaller and nearer together, in the 2400 feet of tunnel.

It has occurred to me that the concentration of the underground water at Goldstone Bottom may perhaps tend to explain the occurrence of the basin there, the water having a freer course there than elsewhere, and therefore escaping more readily to the sea, and carrying away more chalk in solution.

At the time of my visit the tunnels were brilliantly lit up, by means of candles fastened to the sides, so that we could see the length of the tunnels (in one case about 800 feet) and all the springs issuing from the bottom. The large springs were seen to be in connection with joint-planes, which, though for the most part closed, or nearly so, yet, I was assured (by Mr. Baker, who accompanied me), were open where the water came out, so that a man's arm could be thrust in the opening.

Some small inflows of water from the upper part of a tunnel seemed to communicate nearly directly with the ground above, as, though running, or rather gently trickling, at the time (after some wet weather), they had not been seen before, in the dry weather. It was strange indeed to see the great extent of side that was quite dry, damp being the exception, and to think that, were pumping stopped, the whole would be filled with water in 6 or 8 hours.

In the North-eastern tunnel the roof is throughout of one bed, rarely needing support. At the bottom of this bed of chalk there was a thin, but continuous, layer of flint, which, being brittle, had been cleared away. It is curious that the end of this tunnel has struck on an old well, probably one that was made in the early part of the century, when a number of French prisoners of war were encamped on the site of the works.

Some weak places in the tunnels had been strengthened by brick-work; but for the most part the chalk is firm enough to stand.

To conclude, the visit to these important works, so liberally opened for us by the Corporation of Brighton, could not fail to be of the greatest interest to those present, and to be a source of instruction to all interested in the important question of water-supply from the Chalk.

V.—INQUIRY CONCERNING THE DISTRIBUTION OF TEREDO-BORED WOOD IN THE EOCENE.

By J. STARKIE GARDNER, F.G.S.

THE habits and distribution of this marine molluscan pest chiefly concern the engineer and ship-builder at the present day, but in the past their presence is a considerable guide to the geologist as to the conditions under which many of the Eocene beds were deposited. It does not seem to have existed in the Gault sea, for though the drift-wood of this period is riddled by some of its destructive ancestors, such as *Teredina*, Lamarck, and perhaps *Xylophaga*, it is far less completely destroyed than when the true ship-worm has been at work.[1] Something very like it is present in the Chalk; but when we come to the Eocenes, there is no longer any possibility of doubt as to the animal which has made its home in the drifting logs, for they are riddled in the way peculiar to the true ship-worm, and its shell is frequently left in the bore-holes. The distribution of such bored wood in our Eocenes must prove very instructive in many ways, when the habits of the living animal are more thoroughly known. As far as my own observations go, it occurs in the following beds, but I trust many of our numerous local observers will contribute additional and more precise information.

Thanet Beds.—A good deal of the silicified wood from the Thanet series of Herne Bay is bored by Teredo. Mr. Dowker, F.G.S., observes that most of the perforations are parallel with the grain of the wood, and mostly range from $\frac{3}{16}$ to $\frac{5}{16}$ of an inch in diameter, though there are many smaller bores associated with them.

Reading Beds.—I have no recollection of meeting with Teredo-bored wood in this formation.

Woolwich Beds.—Teredo has been recorded from Charlton and Sunderidge. It is probable that all wood from these deposits will prove to be bored by the ship-worm.

Oldhaven Beds.—Teredo is recorded by Mr. Whitaker from Charlton, Sunderidge, and Reculvers.

London Clay.—In reply to my inquiry, Mr. W. H. Shrubsole, F.G.S., has very kindly sent me a response which I cannot do better than quote:—

"Of the very large number of fossil trunks that I have observed, in nearly every case, if not in all, it has been evident that the Teredo borings were on one side of the ovally compressed stem, and in every instance where I have examined these trunks *in situ*, either in the cliff or on the undisturbed clay floor of the foreshore, I have found the borings only on the underside. This seems to show that the Teredo attacked the log when it was floating at the surface, and that it was silted up very soon after becoming water-logged and going to the bottom.

"The upper surface generally has a limestone covering some inches in thickness. The trunks are nearly always cracked up into lengths varying from two to four feet. It is extremely rare to find a log, large or small, that has not been bored. I have just examined a segment of a large fossil trunk which I selected and brought home as being less mutilated by Teredo than any I had seen for a long time, and I find that its appearance quite supports the statement made above.

"Another segment of the same trunk I had cut up transversely into slabs. One of these slabs (polished) is at Jermyn Street, and another, I think, at Cromwell Road Museum. Reference to them will probably show that owing to destructive action on one side the natural axis is eccentric.

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[1] *Teredo* has been recorded from the Jurassics, but the generic identity is, I think, doubtful.

"I have found living Teredo in wreckage and other timber that had been drifting about for some time in the same relative position as in the fossil trunks. W. H. S."

Some of the logs at Sheppey must have been entire trunks of large trees, and they seem to have become water-logged and sunk before the Teredo had penetrated through even to the core, but in the vicinity of London, where wood in a calcified state is found in smaller pieces, it is invariably completely riddled. I only recollect observing it elsewhere at Harwich and Herne Bay, but there is no doubt that most of the wood, except small twigs, is universally bored by Teredo in this formation.

Lower Bagshot Formation.—I cannot trace the occurrence of any bored wood in these beds at Corfe, Studland, Alum Bay, or elsewhere in Dorset and the adjoining borders of Hampshire, neither does Mr. Keeping recollect any at Whitecliff Bay. I have found it, however, in company with Mr. Hudleston, in the cutting near Walton.

Middle Bagshot Formation.—The wood throughout this great formation is invariably completely riddled, except in the lowest beds overlying the Lower Bagshot in the neighbourhood of Poole Harbour and inland to the N.W. of Bournemouth. There is frequently so little of the substance of the wood left that it appears as a mere dark stain in the sand separating the casts of the tubes. The logs in the Bournemouth beds are never large, seldom exceeding three or four feet, and are riddled quite through and through. In a higher part of the series, at Hengistbury, the logs are larger, sometimes five feet long and two or more feet in width, and the bores are relatively gigantic, being upwards of an inch in diameter, sparsely scattered, and obviously the work of a different animal. Wood from the true Bracklesham beds, wherever met with, is invariably bored by Teredo.

Upper Bagshot Formation.—Wood is always more or less bored in these beds, though less extensively so perhaps in the Barton series than in the Bracklesham beds just noticed, for solid pieces occur in the former, but not in the latter. I am indebted to Mr. Keeping for corroborating this observation, and extending it to the same series in Whitecliff Bay, where I had not noticed any wood.

Lower Headon Beds.—Neither Mr. Keeping nor myself have noticed bored wood, at Hordle and in the Isle of Wight, in this formation.

Middle Headon Beds.—Mr. Keeping tells me that wood is invariably bored in the Brockenhurst beds, but I have no notes regarding wood in the beds at Colwell and Totland Bays.

Upper Headon Beds.—No bored wood occurs in these.

Bembridge Series.—Mr. Keeping and myself are confident that no Teredo-bored wood occurs in any part of this series, unless in the brackish series near Whitecliff Bay, where none however has yet been observed. Mr. E. A'Court Smith writes, "I have never noticed Teredo-boring in any of the wood here, though some of the wood is apparently perforated by a species of beetle (or White-Ant?). So great is the perforation in some cases that the wood drops to fragments on being released from the matrix." I find no record of Teredo from the Hempstead beds.

I have never met with any Teredo-bored wood in the Antrim and other northern Eocenes, nor at Bovey Tracey. Additional information would be of importance, especially with regard to the London Basin, where the tubes often remain as hard cores of pyrites, when the wood itself is soft and perishing. They are rounded and blunt and closed at the thick end and open at the thinner end, and in this state are often mistaken for plant-remains such as roots or stems. On one occasion I was sent for to Bournemouth on account of the supposed discovery of fossil canes or reeds *in situ*, these being nothing more than casts of Teredo-boring in a vertical position.

With regard to the habits of the living Teredo, it was, I believe, for a long time assumed to be a purely marine mollusc, and its occurrence in Eocene deposits that were quite obviously of fresh-water origin was a serious stumbling-block. It has gradually been ascertained, however, to ascend very far up tidal rivers; but whether it ever passes up completely beyond the influence of saline water, is a question that appears to be unsettled. It is one, however, which must be set at rest, if we are ever to understand, and be in a position to restore, the physiography of the great river to which the deposition of the entire English Eocene basin is due.

The late Dr. Gwyn-Jeffreys appears to have collected more information bearing on this point than any previous writer, and the following is an extract from his British Conchology, p. 147:—

"*T. Senegalensis*, de Blainv., was discovered by Adanson in the roots of the Mangrove and another kind of tree lining the banks of the Niger, Gambier, and other rivers on the W. coast of Africa, which were only subject to an influx of sea-water for a few months in the year. According to Adanson, the water of these rivers is quite fresh or sweet during the remaining months; and *T. Senegalensis* not only exists, but retains its full vigour throughout the whole year. This statement, however, must be received with some qualification. I was assured by Dr. Welwitsch, the great botanical traveller, that in the tidal rivers of South Africa, the water in the middle stream is fresh, while that of the sides is brackish, and that no kind of Mangrove has been known to live in fresh water. Another sort of ship-worm (*Nausitora Dunlopei* of Perceval Wright) has lately been found in India, inhabiting the river Comer, one of the branches of the Ganges, and a perfectly freshwater stream, that joins the main river at a distance of about 70 miles from the sea. Dr. Kirk, the friend and companion of Livingstone, informs me that he picked up a piece of ebony (*Dalbergia melanoxylon*) on a sandbank in the Zambesi river, the water of which was there always fresh and drinkable 100 miles from the sea—very far beyond the influence of the tide, which never comes more than 10 miles up the creeks of the delta. This piece of ebony was pierced in all directions by a species of *Teredo* having a calcareous sheath. The kind of wood mentioned by Dr. Kirk resembles the ebony of commerce, but is utterly worthless except as fire-wood; and therefore it is not at all likely that the piece in question could have been accidentally brought inland, after being perforated in the sea by *Teredo.* It sinks in water, is rather brittle, much harder and far more compact than either mahogany or teak, and is full of some mineral matter that quickly deadens the edge of any tool. It does not grow on the coast, nor within 50 miles of it on the Zambesi. Dr. Kirk adds that in the bottom planks of the pinnace belonging to the expedition, the ship-worm was also found, with its soft parts attached to the finely sculptured valves. The boat was so riddled that the quartermaster pushed a paint brush through her double planks. This was at Tete, 250 miles from the sea, after the pinnace had remained there six months at anchor. I regret not having space to give *in extenso* Dr. Kirk's interesting account of all the circumstances connected with this discovery. There is not the slightest doubt that the Teredo *observed by him inhabits water which is at all times perfectly sweet and fresh.*"

With regard to its occurrence in fresh water in India, a letter from a member of the Survey appeared in "Nature" of April 19th, 1877: "That the delta of the Irawadi, a tangled maze of creeks, the waters of which are brackish or salt for about half the year, and slightly so, and even potable during the other months. The large canoes which traverse these creeks are much infested by ship-worm, and are fired to get rid of them. I cannot recall any instances of bored wood well above the tide-way, but wherever the water is occasionally brackish, thus far the worms seem capable of settling. Perceval Wright has described *Nausitoria Dunlopei* from the rivers of Eastern Bengal as *Novaculina gangetica.* The two Burmese species of *Scaphula* are both estuary forms, whereas the type of the genus in the Ganges is found a thousand miles from the sea."

Dr. W. T. Blanford, F.R.S., in reply to my question, almost disposes of the contention that *Teredo* actually becomes a *bona-fide* freshwater mollusc, so far as India is concerned. He writes: "I know nothing of any occurrence of *Teredo* in Indian freshwater, and as I for many years paid a good deal of attention to Indian freshwater shells, I should be much surprised if *Teredo* were really found in fresh water there. The genus, however, abounds in the salt and brackish water of estuaries; all dead wood and even dead branches of living trees being riddled with borings of several different forms. I have seen them abundantly in the deltas of the Ganges and Irawadi rivers. The estuarine molluscan fauna is very rich and peculiar in India. At times of flood the quantity of water pouring down the rivers is so great that estuaries become temporarily fresh, and in this case estuarine forms may be found living in what is for the time freshwater."

There is still, however, considerable doubt as to the limits to which the ship-worm penetrates in Australian rivers, and naturalists with whom I have conversed seemed under the impression that it might be met with above rapids, and altogether out of reach of even an occasional mixture of brackish water. The only further information I have, is contained in a letter to "Nature," May 3rd, 1877, in which Mr. Arthur Nicols, speaking from recollection, says that "*Teredo navalis* is certainly able to endure a long continuance of freshwater. At Brisbane the river is subject to freshes, one of which lasted ten days, when the flood was so powerful that ocean steamers could not get up. Salt-water is said at floods to ascend thirty miles beyond the town, which is itself twenty-five miles from the Pacific,—but the ebbs are more fresh than salt. Piles have to be protected with Muntz metal."

It will be seen that more definite information is required on all the points raised. There is said to be a freshwater *Carcharias* in the rivers of Fiji, and it would be interesting to learn whether it also ever lives wholly beyond the tidal reaches, or merely ascends rivers, as seals will, in search of food.

It thus appears, so far as we can go at present, that Teredo chiefly flourished during our Eocene time in waters that were clearly estuarine. The purely salt water reaches of the great river, such as those in which the London Clay and Bracklesham beds were deposited, were less favourable to its development than the almost fresh-water reaches in which the Bournemouth fresh-water beds and the Lower Bagshot of the London Basin were formed. In this last class of deposits there is no other sign whatever of aquatic life, either fresh or salt, and we are forced to conjecture that perhaps frequent change from quite fresh to quite salt water was the excluding cause. In what were perhaps more littoral marine beds, out of the influence of the river, such as those of Herne Bay and Highcliff, the Teredo seemed comparatively to languish, and it is quite excluded from the higher reaches of the river in which the Lower Bagshots of Studland and Corfe were formed, and which from the presence of *Unio* would appear to have been wholly freshwater. It had no place in the lacustrine deposits of Headon and Bembridge, and even the brackish and salt waters of these formations seem to have been quite unfavourable to it, being, it appears, from their teeming life, too permanently either fresh or salt. Without its presence we might never have suspected that many important masses of sediment containing terrestrial vegetation had ever been formed within the influence of the tides of the sea. Sufficient has been said to illustrate the peculiar local significance that the record of this destructive mollusc may possess with regard to the origin of a formation. It is noteworthy that the Eocenes possess three distinct types of *Teredo* which have not as yet been distinguished.

NOTICES OF MEMOIRS.

I.—Report on the Geology of the Kimberley District, Western Australia. By Edward T. Hardman, etc., of H. M. Geological Survey of Ireland. Fcap. pp. 22, 16 Plates, Map. (Perth, W.A., 1884.)

THE country described in this very excellent report comprises that portion of Western Australia extending from Roebuck Bay inland to the Leopold Ranges, and between Port Usborne, and a line running eastward to the south of the Fitzroy River (lat. 16° 35′ and 18° 30′ S., long. 122° 10′ and 126° 50′ E.), including in all 12,800 square miles.

It may be generally described as a vast undulating plain, rising gradually from the sea-coast to a height of 200 ft., broken by isolated hills and some extensive mountain ranges, the highest reaching 2000 ft. above the sea-level. The district is unusually well watered, The geological formations represented over this immense tract of country consist of Recent accumulations, Pliocene sand and gravels, Carboniferous sandstones, grits, and limestone, and Metamorphic rocks.

The Recent accumulations are—(*a.*) Wide sand-flats locally termed "Marshes," along the sea-coast, and extending inland for miles, the most striking instance being the great plain from Roebuck Bay to Barlee Spring. The contained fossils are of recent species. (*b.*) Alluvium deposited by successive floodings of the rivers, estimated as equal to 3355 square miles, or 2,147,200 acres. But taking into consideration an average thickness of 30 ft., we have the "enormous weight of 103,924,480,000 tons of silt and mud carried down by these rivers" of the Kimberley District. (*c.*) River-gravels accumulated in the upper reaches of many of the streams (notably in the Usborne district), the pebbles often reaching six to nine inches in diameter. These subdivisions comprise the "Recent" formations described by Mr. Hardman.

Certain deposits of reddish sand, with small pea-like nodules of ironstone, and other rocks, with beds of red and yellow-ochreous earth, are provisionally classed as Pliocene. They are termed the "Pindan" sands and gravels, and occupy a very large area, and have been proved to be at least 30ft. in thickness. They are unfossiliferous, "but there can be little question that they are of comparatively recent age."

The Carboniferous rocks appear to be separable into an upper and lower series. The upper consists of sandstones, and forms the chief mountain ranges, extending as much as 190 miles into the interior, and are over 1000 ft. in thickness. *Lepidodendron, Calamites*, and *Sigillaria* are said to occur in these beds, but no traces of coal have been met with. The apparently overlying Carboniferous Limestone extends in a line N.W. and S.E. directly across the Kimberley district, with a maximum breadth of thirty miles, and an estimated thickness of 1000 ft. "It is a light-coloured, compact, brittle, splintery, more or less Magnesian Limestone," and bears a strong resemblance to the Upper Carboniferous Limestone of Ireland. It is in places very cavernous. Fossils were met with abundantly at certain localities, and the list of species given by Mr. Hardman clearly bears out the age assigned to the beds.

The Metamorphic rocks are divided into two classes—the schistose, including gneiss schist and metamorphic granite, and quartzites and altered grits. The former are widely developed along the base of the Leopold Range, and contain quartz veins, and the common garnet in great abundance. The quartzites and altered grits constitute the mountainous country in Kimberley, and are interstratified with red and yellow sandstones, conglomerates, and grits.

Dykes of felstone, of later age than the Metamorphic rocks, are also met with. No precious metals were discovered, but Mr. Hardman believes in their discovery being probable in this series.

The Report is accompanied by sixteen geological views, and a very good map.

II.—The Lias of Fenny Compton, Warwickshire.

MR. THOMAS BEESLEY, F.C.S., has just issued this paper with additions and corrections to the end of 1885. The author describes the situation of Fenny Compton as a little station on the Great Western and East and West Junction Railways, on the Warwickshire side of the boundary between that county and those of Oxford and Northampton, eight miles from Banbury and twelve from Leamington, and at an elevation of nearly 400 feet above the sea. He points to the Burton Hills, whose bold escarpment forms so pleasing a feature in the landscape, as the extremity of the Marlstone promontory which stretches from the Cherwell valley into the Lower Lias bay of Warwickshire. He then directs attention to the sources of the Leam, the Cherwell, and the Nene, flowing respectively to the Severn, Thames, and Ouse, which sources are all within a circle of one mile radius, in the high ground above the Marlstone escarpment of Northamptonshire, a short distance east of the Burton Hills. The railway at Fenny Compton passes for nearly three-quarters of a mile through a cutting which exposes a section of the lowest zone of the Middle Lias, which, with the exception of those on the Dorsetshire and Yorkshire coasts, is probably the most extensive to be met with in England. The zone of *Ammonites Jamesoni* which occurs at Fenny Compton is, with the two others next above it, referred to the Lower Lias in the maps and memoirs of the Geological Survey of England; but, under the circumstances, the author prefers the continental arrangement. Proceeding southwards upon the East and West Junction line, the banks rise rapidly, exposing a bluish-black shale, fine in texture and rather marly. With one doubtful exception, none of the Ammonites of the Lower Lias have been found there. Some geologists have attributed this bed, and a good deal above it, to the "Raricostatus zone" of the Lower Lias, but Professor Tate, who had carefully examined it, agreed with the author that there was an error in the conclusion.

The bed soon presents unmistakable Middle Lias characteristics in the form of parallel lines of pale grey or reddish flattened nodules. They are much more calcareous than the clay in which they are embedded, and contain a notable amount of phosphoric acid, chiefly combined with lime. There are five lines of conspicuous nodules in the 40 feet of shale. The lower nodules, like the shale in which they lie, are rather poor in fossils, though both become richer in higher ground. The author possesses a small one containing on its surface 50 specimens belonging to more than 20 species, one of which is a *Discina*. About a quarter of a mile from the station, two noticeable bands of stone occur about 40 feet above the base of the section. The upper stone is separated from the lower by 4 ft. 6 in. of dark blue clay with many fossils. It is of the same mineral character and appearance as the lower; but contains corals of the genus *Montlivaltia*, while corals are no longer present in the lower. The *Spiriferinæ*, which play so important a part in the fauna of the upper stone band, as well as the corals and *Waldheimia numismalis*, are absent from the Yorkshire Lias. The dip of the beds is distinctly to the south, as the stone bands sink below the surface, at a distance of about a third of a mile beyond the spot where they first appear. The true dip is about three-fourths of a degree. Above the stone bands, the shale gradually becomes greyer, rougher, and more lumpy, many of the lumps containing impressions of fucoids.

The following is a detailed section of the Fenny Compton beds:—

	Ft.	in.
Rough shaly clay	20	0
Band of calcareo-argillaceous nodules		2
Shale	10	0
Band of nodules with *Am. Henleyi*, *A. Ibex*, *A. Maugenetii*, *A. Valdani*		3
Shale	8	0
Band of nodules with *Am. Maugenetii*, and Fucoids		2
Shale, with Belemnites	2	0
Rough, shelly, argillaceous limestone, with *Am. Valdani*, and *A. Jamesoni*, *Spiriferina verrucosa*, *Belemnites clavatus*, *Lima Hettangiensis*, *Waldheimia numismalis*, *Rhynchonella rimosa*	1	0
Shale, with Belemnites	4	6
Rough, shelly, argillaceous limestones with *Am. armatus* (*young*). *Pecten priscus*, *Limea acuticosta*, *Gryphæa obliquata*, *Cardinia attenuata*, *Rhynchonella rimosa*. Corals		9
Shale	1	8
Band of nodules		3
Shale	3	0
Band of nodules with *Pecten calvus*, *Terebratula subovoides*		3
Shale	14	0
Band of nodules		2
Shale	5	0
Band of nodules		2
Shale	3	6
Band of nodules		2
Shale	22	0
	97	0

III.—Annalen des k. k. Naturhistorischen Hofmuseums; redigirt von Dr. Franz Ritter von Hauer. Band I. No. 1. Jahresbericht für 1885, von Dr. F. von Hauer. (Wien: 1886.)

Annals of the Royal Natural History Museum. Edited by Dr. F. von Hauer. Vol. I. No. 1. Annual Report for 1885, by Dr. F. von Hauer. (Vienna: 1886.)

THIS report contains a review of the progress made in the organization of the New Natural History Museum of Vienna under the superintendence of the well-known mineralogist, Dr. von Hauer, the successor of the late Dr. F. von Hochstetter. Until lately, the various Natural History collections of the Austrian capital were deposited in different buildings, under independent management, but they have now been brought together in a magnificent edifice expressly constructed to receive them. The Museum includes the following five divisions: (1) Zoological; (2) Botanical; (3) Mineralogical and Petrographical; (4) Geological and Palæontological; (5) Anthropological and Ethnographical. Dr. A. Brezina and Theodor Fuchs are the keepers of the third and fourth departments respectively. The mineralogical collection is noted more particularly for its meteorites, of which there are 1207 specimens from 365 different localities; and the special forte of the palæontological division is the splendid collection of Tertiary mollusca.

A special library is being formed in connection with the museum, and we notice with pleasure the facilities provided for carrying forward original research whether by the museum officials or by voluntary independent investigators.

The present number is intended as the first of a series in which it is proposed to publish, together with the museum report, original memoirs on various natural history subjects.

IV.—Die Crinoïden des norddeutschen Ober-Devons. Von A. von Kœnen, in Göttingen. Neues Jahrbuch für Mineralogie, etc., 1886, Bd. I. p. 99–116, Plates I.—II.

OWING to their defective state of preservation, very little has hitherto been known of the Crinoids of the Upper Devonian strata of North Germany. Prof. von Kœnen in this paper gives the results of a critical examination of specimens which he has for many years been collecting, as well as of those preserved in the Museums of Bonn, Berlin, and Aix-la-Chapelle. From a comparison with the forms from the Famennien group of Senzeille in Belgium, described by Fraipont, the author has been able to determine the position of the anal plate and the composition of the ventral roof of the calyx of the different species; characters, which the author regards as of special value in the determination of species. The following species are described and figured:—*Melocrinus gibbosus*, Goldf., *M. hieroglyphicus*, Goldf., *M. Chapuisi*, Dewalque, *M. Dewalquei*, n. sp., *M. Benedini*, Dew.-Fraipont, *Hexacrinus infundibulum*, n. sp., *H. angulosus*, n. sp., *H. verrucosus*, Dewalque, *H. tuberculatus*, n. sp., and *Storthingocrinus sphæricus*, sp. n. G. J. H.

V.—Records of the Geological Survey of India, Vol. XIX. Part 1, 1886.

THIS part contains, with other papers, the Annual Report of the Geological Survey of India by Mr. H. B. Medlicott, in which attention is more particularly called to the discovery, by Dr. Warth, of Palæozoic fossils in the Salt Range of the Punjab, in strata, associated with a noted Boulder-bed, which have hitherto been regarded as belonging to the Cretaceous series. The fossils, which have been determined by Dr. Waagen, include several species of *Conularia*, *Bucania*, *Nucula*, *Atomodesma*, *Aviculopecten*, *Discina* and *Serpulites*, some of which occur in Carboniferous strata in Australia, and others are related to species from the Carboniferous Limestone of Belgium. A further interest attaches to this discovery of Carboniferous fossils in connection with the Boulder-bed in the Salt Range, from the probability that this bed may be identical with the Talchir boulder glacial deposits found almost everywhere at the base of the Gondwana rocks of Peninsular India. These in turn have been correlated with remarkable Boulder-beds, believed to be due to ice-action, occurring in the Carboniferous series of Australia. Mr. R. D. Oldham has lately visited Australia, and contributes, in this part, a highly important memorandum on the subject. This further evidence strongly supports the original views of Dr. Blanford as to the Palæozoic age of the Lower Gondwana deposits, and, as Mr. Medlicott remarks, "it would be the first clear and broad case to confirm the assertion, made twenty-five years ago by Prof. Huxley, when introducing the term 'homotaxis,' for it shows that a full-blown Mesozoic flora in one region of the earth was contemporaneous with a full-blown Palæozoic flora in another region."

Under "Afghan and Persian Field Notes," Mr. C. L. Griesbach, who accompanied the Afghan Boundary Commission as geologist, gives an outline sketch of the various geological formations, which range from the Post-Tertiary to the older Palæozoics, occurring in the Herat Valley and Khorassan.

The other papers in this part are "Notes on the Section from Simla to Wangtu," by Col. McMahon, and an excellent "Report on the International Geological Congress of Berlin," by Dr. W. T. Blanford, F.R.S. G. J. H.

VI.—CONTRIBUTIONS À LA GÉOLOGIE DES PAYS-BAS. Par Dr. J. LORIÉ. RÉSULTATS GÉOLOGIQUES ET PALÉONTOLOGIQUES DES FORAGES DE PUITS À UTRECHT, GOES ET GORKUM. Extrait des Archives Teyler, Series II. tom. ii. Large 8vo. pp. 132, and 5 lithographic plates. (Haarlem, 1885.)

THE opportunities of studying the structure of the earth's crust in a flat country like the Netherlands are indeed few and far between. There are no coast or valley sections, and owing to the general level character of the country, scarcely any artificial cuttings are required for the railways. Under such circumstances, well-sinkings afford the best, and almost the only means of ascertaining the stratigraphical succession. In the course of the last few years, three important sinkings have been made in this country, at Utrecht, at Goes on the island of South Beveland, and at Gorkum in South Holland. The first of these was carried to the depth of 369 mètres, that at Goes to 223·9 m., and that at Gorkum to 182 m. beneath the surface, which, in each case, did not exceed 5 m. above the sea-level. The distribution and the characters of the fossils met with in these well-borings have been carefully investigated by Dr. Lorié, and this memoir contains critical descriptions and figures of the different species and tabular lists of their occurrence in the beds at different depths, and a comparison with those in strata of corresponding age in Belgium and East-Anglia.

The strata pierced in these well-borings consist entirely of beds of gravel, sand and clay, of Tertiary and Quaternary age, some barren of fossils, others with shells, bryozoa and other fossils. There are 131 species enumerated, all of which have been previously described. In the Goes boring the entire thickness of the Pliocene is penetrated. The Lower Pliocene or Diestien, the equivalent of the Coralline Crag, has a thickness of 37 mètres. It contains a certain proportion of Polyzoa and appears to have been deposited in a tolerably deep sea. It rests upon the Rupélien clay of Middle Oligocene age. The Upper Pliocene or Scaldisien, the equivalent of the Red Crag of East-Anglia, has a thickness at Goes of between 23 and 29 mètres. Above this comes the so-called Diluvial beds, about 47 mètres in thickness. At Utrecht the Diestien beds have a minimum thickness of 125 m. and their base is not reached. They are principally greyish-green sands with intervening bands of clay, and the absence of Polyzoa and the broken condition of the shells indicate a shallower sea than at Goes. The Scaldisien or Red Crag has a thickness of 82 m., and there are above it beds of Quaternary and Recent age 162 m. in thickness. At Gorkum the base of the Scaldisien or Red Crag was not reached at the depth of 182 m. This deposit has thus a minimum thickness of 62 m., and from the fragmentary and triturated shells therein, it appears to be of littoral origin. Above this are freshwater beds, 28 m. in thickness, of Quaternary age. With the exception of the first 12 m. of recent deposits, the intervening strata 80 m. in thickness are also of Quaternary age.

This memoir is a valuable contribution to the history of the later fossiliferous strata in a new area, and it has a special interest to the student of the corresponding beds in East-Anglia. G. J. H.

REVIEWS.

I.—BULLETINS OF THE UNITED STATES GEOLOGICAL SURVEY. Nos. 1–19. (Government Printing Office, Washington, 1884–5.)

IN addition to the large volumes of the Annual Reports, and the magnificent Monographs, the United States Geological Survey are also issuing a series of Bulletins, each on a special subject and complete by itself. Nineteen of these papers have already been published. Some of them, it is true, treat of subjects which are but remotely connected with geological research, as, for instance, "Gold and Silver Conversion Tables," giving the coining value of Troy ounces of fine metal, etc., and "Boundaries of the United States and of the several States and Territories;" others, though not directly geological, are of great practical value to all geologists working in the United States and Canada, as, for example, "A Dictionary of Altitudes in the United States" and "Elevations in the Dominion of

Canada;" whilst others are of interest to geologists generally. We regret that space does not permit us to mention more than the titles of the Bulletins of this latter description; it may suffice to state that their respective authors are all well-recognized authorities on the subjects of which they write. The following are on palæontological matters:—"On Mesozoic Fossils," by Dr. C. A. White, who also contributes papers "On the Mesozoic and Cenozoic Palæontology of California," and "On Marine Eocene, Freshwater Miocene, and other Fossil Mollusca of Western North America." "On the Fossil Faunas of the Upper Devonian along the Meridian of 76° 30′," by Prof. H. S. Williams. "On the Cambrian Faunas of North America," by C. D. Walcott. "On the Quaternary and Recent Mollusca of the Great Basin," by R. E. Call; and "On the higher Devonian Faunas of Ontario County, New York," by J. M. Clarke.

The following treat of petrological and mineralogical subjects:—"On Hypersthene-Andesite and on Triclinic Pyroxene in Augitic Rocks," by Whitman Cross, with a geological sketch of Buffalo Peaks, Colorado, by S. F. Emmons; "On Secondary Enlargements of Mineral Fragments in certain Rocks," by R. D. Irving and C. R. Vanhise; "A Crystallographic Study of the Thinolite of Lake Lahontan," by E. S. Dana; and "On the Development of Crystallization, etc.," by Arnold Hague and J. P. Iddings.

Besides the above, Mr. George F. Becker contributes "Notes on the Stratigraphy of California," and MM. Jules Marcou and J. B. Marcou, "A Catalogue of Geological Maps of America (North and South) 1752–1881."

These Bulletins, in all cases where the subject-matter requires illustration, are furnished with well-executed plates, in one instance these are beautifully coloured. Further, these papers will not be less appreciated on account of the fact that they are published at such moderate prices as to bring them within the means of all geologists.

G. J. H.

II.—MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA. PALÆONTOLOGIA INDICA. Ser. X. INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA, Vol. III. Parts 7 and 8. SIWALIK CROCODILIA, LACERTILIA AND OPHIDIA; AND TERTIARY FISHES. By RICHARD LYDEKKER, B.A., F.G.S., with ten plates, xxviii.–xxxvii. (London, Trübner & Co.)

WE noticed the previous issue of this important serial of Indian Palæontology in August last (see GEOL. MAG. 1885, Dec. III. Vol. II. p. 371). The present part, which completes vol. iii., contains the Crocodilia, which occupy seven plates, some fragmentary remains of Lacertilia and Ophidia, Sharks, Siluroid fishes, etc.

The Crocodilia comprise only two species of true Crocodile, namely, *C. sivalensis*, Lyd., and *C. palæindicus*, Falc.; five species are referred to Geoffroy's genus *Gharialis*, namely, *G. gangeticus*, *G. hysudricus*, *G. curvirostris*, *G. leptodus*, *G. pachyrhynchus*, and a single species to a new genus, *Rhamphosuchus*, viz. *R. crassidens*. Some of these old Gharials attained to enormous size, judging by the proportions of the parts preserved in the Falconer and Cautley Collection in the British Museum (Natural History), Cromwell Road, and in the Geological Survey Museum, Calcutta. Thus, "*G. pachyrhynchus*, from the Lower Siwaliks of Sind, was between two and a half and three times the size of full-grown existing specimens of *G. gangeticus*, which attains a total length of twenty feet. If the same proportions obtained in this fossil species, its total length would have been from fifty to sixty feet." (p. 21.)

A portion of a humerus of a *Varanus* indicates in a similar manner a lizard perhaps twice the size of the largest existing species (*V. salvator*), which, according to Mr. Theobald, attains a length of nearly seven feet; so that *V. sivalensis*, Falconer, may have been as much as from 12 to 14 feet long.

This Memoir also makes us acquainted with a series of ophidian vertebræ referred by the author to *Python*, and probably identical with the *Python molurus*, Linn. sp.

Many of the remains here described and figured were collected thirty years ago or more by the late Sir Proby T. Cautley, and a few have been described already by Dr. Hugh Falconer, F.R.S.

The fish-remains described embrace teeth of sharks, referred to *Carcharias*, sp.; and *Carcharodon*, sp., from the Siwaliks; palatal teeth of Rays, *Myliobatis*, from the Eocene of Kach; teeth of *Sparidæ* (*Capitodus*); *Ophiocephalidæ*, cranium of *Ophiocephalus*, and numerous cranial plates of *Siluridæ*, etc., very like, or identical with living Indian forms. This part also includes the Title-page, Index, and some Introductory Observations to complete Vol. III. of Series X. Some excellent figures of *Mastodon*-molars accompany and illustrate the Introductory Chapter, with which, when bound, the volume will commence.

This great work, carried out under the able administration of the Superintendent of the Geological Survey of India, Mr. Henry B. Medlicott, M.A., F.R.S., has of late years been wholly prepared by Mr. Lydekker, and printed, and illustrated, in England, and has thus had the best possible care and every advantage in its production; yet, nevertheless, it is sold at a *lower price* than any similar publication in Europe or America. We wish the publications of the Indian Survey the success they so richly and honourably deserve, and we compliment Mr. Lydekker, the author of the present volume, upon the completion of this section of his very excellent Indian Monograph.

It is interesting to mention, for the information of English Palæontologists, that a large number of the type-specimens figured in the volumes of the "Palæontologia Indica" are to be seen in the cases of the Geological Gallery of the British Museum (Natural History); so that this magnificent work is in a measure an illustrated and descriptive catalogue, not only of the Calcutta Museum, but in part also of our own Indian collections at home.

III.—CATALOGUE OF THE FOSSIL MAMMALIA IN THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W. PART II.[1] CONTAINING THE ORDER UNGULATA, SUB-ORDER ARTIODACTYLA. By RICHARD LYDEKKER, B.A. 8vo. pp. i.–xxii. and 3241, illustrated by 39 Woodcuts. (London, 1885, printed by Order of the Trustees.)

WITH praiseworthy zeal Mr. Lydekker has finished another volume of the Catalogue of Fossil Mammalia in the Geological Department of our National Museum; indeed we are assured a third part is now actually passing through the press and will be issued this Spring.

The present section is a very large one (nearly 350 pages in extent), and is illustrated by thirty-nine woodcuts. It is confined entirely to one sub-order of the Ungulata, or hoofed-animals, the ARTIODACTYLA, or even-toed Herbivora. In this sub-order are included the *Bovidæ*, *Giraffidæ*, *Cervidæ*, *Camelidæ*, *Tragulidæ*, the *Suidæ*, *Phacochæridæ*, and *Hippopotamidæ*, all of which families have *living representative species;* also the families *Dichodontidæ*, *Cœnotheriidæ*, *Anoplotheriidæ*, *Oreodontidæ*, *Merycopotamidæ*, *Anthracotheriidæ*, *Chæropotamidæ*, and *Listriodontidæ*, all the species of which are *extinct*. The following definition of the Artiodactyla may be acceptable.[2] In this sub-order the premolar and molar teeth are not alike, the former being single, and the latter two-lobed. The last lower molar of both the first and second dentition is almost invariably three-lobed. The nasal bones are not expanded posteriorly. They have no alisphenoid canal. The dorsal and lumbar vertebræ together are always nineteen, though the former may vary from twelve to fifteen. The femur is without a third trochanter. The third and fourth digits of both feet are almost equally developed and their ungual phalanges are flattened on their inner or contiguous surfaces, so that each is not symmetrical in itself; but when the two are placed together, they form a figure symmetrically disposed to a line drawn between them. In other words, the axis or median line of the whole foot is a line drawn between the third and fourth digits, while in the Perissodactyles (uneven-toed Ungulates) it is a line drawn down the centre of the third digit. The distal articular surface of the astragalus is divided into two nearly equal facets, one for the navicular and one for the cuboid bone. The calcaneum has an articular facet for the lower end of the fibula.

The Artiodactyla are naturally separable into two very well marked subdivisions, namely :—

A. The SELENODONTA—including the numerous extinct genera and also the existing types of true Ruminants, and

B. The BUNODONTA—containing the families of the *Hippopotamidæ* and the *Suidæ*.

Both these divisions are very well characterized by their dentition.

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[1] Part I. of this Catalogue—containing the Orders Primates, Cheiroptera, Insectivora, Carnivora, and Rodentia—was noticed in the GEOL. MAG. 1885, Decade III. Vol. II. p. 321.

[2] See Prof. Flower's Article "Mammalia," Encyclop. Britannica, 9th. edit. vol. xv.

The Selenodont (crescent-shaped) type of dentition is closely associated with the Ruminants and evidently has a direct relation with the cud-chewing habit of the Artiodactyle; whilst the Bunodont (or hill-toothed type) are well exemplified in the molar teeth of both the pig and river-horse, a pattern of tooth not met with out of this division save in certain Mastodons and in the teeth of *Halitherium*.

With regard to a large number of extinct forms, their true affinities are of course somewhat conjectural; nevertheless we may pretty safely infer that they were very near to, if not actually to be classed with the Ruminants proper (where the teeth are known). Mr. Lydekker commences his catalogue with the *Bovidæ*, under which section are included the Oxen, Bisons, Sheep, Goats, Antelopes and Giraffes. Following Boyd Dawkins and other authors, Mr. Lydekker sinks the great *Bos primigenius* into a mere gigantic ancestor of *Bos taurus*, and he does the same with the little *Bos longifrons*.

The other bovine species which remain are all foreign and Indian forms. The Bison retains its distinctness, and the Buffalo with its various Indian species. Then follows the Musk-sheep, which appears to have two extinct Pleistocene relatives in North America (probably only local varieties), about which little is known.

Succeeding these are the Sheep, Goats, Gazelles, Antelopes, completing the hollow-horned ruminants. Next after these are placed the Giraffidæ, with which are included the extinct genera *Sivatherium*, *Bramatherium*, *Helladotherium*; this last was formerly considered as the hornless female of *Sivatherium*, but it is now established as a distinct genus by Gaudry and Lartet, and also by Rütimeyer. Remains of the true Giraffe are also found fossil in India and elsewhere.

The solid-horned Deer-tribe follow next in order, with rugged branching antlers of *true bone* without a horny sheath, but covered during their growth with vascular integument coated with short hair. When their growth is finished, the supply of blood is cut off, the skin dies and peels off, leaving the bone bare and insensible, and after a time, by a process of absorption near the base, it becomes detached from the skull and is "shed," an event which occurs annually. After a time a new pair of horns are developed from the peduncles or base of the original pair. The collection affords examples of 38 species of *Cervidæ*—including the Roebuck, Elk, Reindeer, Gigantic Irish-deer, Fallow-deer, Red-deer, and a long series of extinct species, among which *Cervus tetraceros* from the Pliocene of France, and the *Cervus giganteus* from Ireland, are the most interesting and uncommon forms of simple straight-tined, and broadly palmate types.

The Camels offer no interest to the palæontologist, as they appear to have undergone scarcely any modification from existing species; but many of the ten extinct families which follow date back to the Eocene, such as the *Anoplotheriidæ*, the *Anthracotheriidæ*, the *Cænotheriidæ*, etc.

If we except the *Anoplotherium*, the *Dorcatherium* and some few others, the greater number of these species are founded merely on teeth, jaws, etc., and but seldom upon associated skeleton remains;

from what we do know, however, concerning these earlier species, they are seen to be of the greatest interest, as offering forms intermediate in dentition, by which the ruminants and non-ruminants can in a measure be connected together, and also the Perissodactyla and Artiodactyla.

The *Suidæ* are a very remarkable group, being connected by the Chevrotains with the Deer-tribe (and possibly also with the Perissodactyla and Proboscidea, if not with the Sirenia also in past times).

The principal sources whence these early types of Mammalia have been obtained are from the Eocene freshwater beds of Hempstead in the Isle of Wight, the Headon beds, Hordwell, Hampshire; Vaucluse, Débruge, Montmartre, Caylux and many other localities in France; Hesse-Darmstadt in Germany, Pikermi in Greece, and the Siwalik Hills, India.

Some of the most ancient progenitors of the pig-tribe (*Elotherium*) also date back to the Eocene of Hempstead and the Lower Miocene of France. The *Hyotherium* is also regarded as an ancestral form of *Sus* or *Dicotyles*.

Sus giganteus and *Sus titan*, both from the Indian Siwaliks, were amongst the very largest ancestral forms of the Pig family.

The *Hippopotamidæ*, of which a short notice was given in the March Number of the GEOLOGICAL MAGAZINE (p. 114), appear at a less early date than the pigs, but are of extreme interest. They are confined to the old world, over which they seem to have been very widely distributed in Pliocene and Quaternary times, but they are restricted now to the rivers and coasts of the African continent.

It is hardly possible to over-estimate the advantage derived by the publication of these Catalogues. They are an embodiment of all the (too-frequently) unwritten traditions concerning specimens in our grand National Collection, and Mr. William Davies has largely contributed, by his unostentatious, but earnest labours, to bring the remains of the fossil Mammalia in the Geological Collection into such a state as to enable them to be catalogued by Mr. Lydekker, a task too, in which, as stated in the preface, he has taken no small share. It is gratifying to be able to state that this portion of the geological galleries is in a highly satisfactory state, and reflects the greatest credit on the staff who have arranged it in so admirable a manner.

IV.—CATALOGUE OF THE PALÆOZOIC PLANTS IN THE DEPARTMENT OF GEOLOGY AND PALÆONTOLOGY, BRITISH MUSEUM (NATURAL HISTORY). By ROBERT KIDSTON, F.G.S. 8vo. pp. viii. and 288. (London, 1886, printed by Order of the Trustees.)

MR. ROBERT KIDSTON has been favourably known for some time past as a diligent worker in fossil Botany, and he has confined his attention mainly to the plant-remains of the Coal-formation.

Having named and catalogued the Coal-plants in the Museum of Science and Art, Edinburgh, and also contributed several papers to scientific journals on palæobotanical subjects, he was entrusted in 1883 with the task of naming and cataloguing the Palæozoic plants in the Geological Department.

The present work, which was only completed at the end of 1885, is the result.

The plants catalogued are divided into Permian, Carboniferous, Devonian, and Silurian, of which the Carboniferous form by far the largest group.

The	Permian contains	39	species.
,,	Carboniferous contains	218	,,
,,	Devonian ,,	38	,,
,,	Silurian ,,	10	,,

The total number of recognized species represented in the Collection being 305.

It is probable that this number might be greatly increased, and that it does not represent more than a quarter of the total number of fossil plants described from the Palæozoic rocks of the whole world.

The method adopted by the author has been to give a *complete bibliography* of each species; this has entailed an enormous amount of labour, and largely serves to increase the bulk of the present catalogue. Should a new Edition be prepared, we would recommend the author to eliminate all but the important and essential references, and so thereby to greatly reduce the number of pages, whilst largely increasing the real usefulness of the work for purposes of reference.

Another feature of this work consists in the critical remarks, often extending to essays of from one to five pages in length, on questions bearing upon the structure or interpretation put by various authors on the fossil plant-remains recorded in the Catalogue.

Here is an example of one of Mr. Kidston's dissertations taken at random from the Catalogue:—

LEPIDOPHLOIOS, Sternberg, 1825.

Versuch eines geognostisch-botanischen Darstellung der Flora der Vorwelt, vol. i. fasc. iv. p. 13.

Lepidophloios laricinus, Sternberg.

Lepidophloios laricinus.
Boulay, Terr. Houil. du Nord de la France, p. 38.

[Here follow 41 references to works by various authors in which this genus is quoted. These we omit.]

(?) *Ulodendron tumidum.*
Carruthers, Monthly Micro. Journ. p. 154, pl. xliii. figs. 5, 6, 7, 1870.

Remarks.—It has been shown by Feistmantel, in his Steinkohlen-Flora von Kralup in Böhmen,[1] that *Halonia*, Lindley and Hutton, is only a fruiting branch of *Lepidophloios laricinus*, Sternberg, and later the same relationship of *Halonia* to *Lepidophloios* has been further explained by Dr. Macfarlane (Trans. Bot. Soc. Edinb. vol. xiv. p. 181, pls. vii. and viii.[2]). These figures alone, one would think, were sufficient to place the affinities of *Halonia* outside the circle of discussion, but notwithstanding the conclusive evidence they afford on this point, the view held by these writers has not been universally accepted.[3]

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[1] Abhandl. der k. Böhm. Gesellschaft der Wissensch. vi. Folge, vol. v. 1871.

[2] Dr. Macfarlane's *Lepidophloios* is not *L. laricinus*, Sternberg, but a new species for which I propose the name of *Lepidophloios Scoticus*.

[3] See Renault, Cours d. Bot. Foss. p. 63, 1882.

Mr. Carruthers has also figured a specimen of *Halonia* attached to *Lepidophloios*,[1] which is in the Collection. The conclusion arrived at by him was very similar to that mentioned by Feistmantel, that *Halonia* was only a condition of *Lepidophloios*. Both on the Halonian-branch and the main stem of this example some of the characteristic leaf-scars of *Lepidophloios* are shown. Those on the *Halonia* portion are normal in form and point downwards, but on the main stem from some cause, perhaps pressure or distortion during or after mineralization, the leaf-scars are arranged at right angles to the direction they ordinarily hold on the stem; hence the two lateral angles of the leaf-scar lie parallel to the direction of growth, and the scar of the vascular bundle so twisted round, occupies one of the lateral angles.

In his last memoir on the "Organization of Fossil Plants of the Coal Measures,"[2] Dr. Williamson gives a figure (pl. xxxiv.) of *Halonia* attached to a Lycopodiaceous stem. He says,[3] "In my second memoir (Phil. Trans. 1872, p. 222), read in June, 1871, I said, 'I have little doubt but that *Halonia* was a fruiting branch of a *Lepidodendron*;' and in a note added in April, 1872. I affirmed *absolutely*, 'First, that *Halonia* belongs to the upper branches of a Lepidodendroid tree, consequently it cannot be a root;' 'secondly, we learn that *Halonia* is a specialized branch of a Lepidodendroid tree that is not itself a *Halonia*.'" . . . "The specimen now described is unquestionably not a *Lomatophloios*, but a true *Lepidodendron*." In describing his specimen, he says further (p. 468), that at the lower portion of the branch the leaf-scars have exactly the same form as those of *L. selaginoides* and *L. elegans*, Lindley and Hutton. I have already mentioned that the leaf-scars on the specimen described by Mr. Carruthers are so turned round on the stem that instead of their greater diameter being transverse to the stem, as is normally the case in *Lepidophloios*, it is vertical. Dr. Williamson's figure does not show clearly the form of the scars further than that the vertical diameter of those on the lower part of the stem seems greater than their transverse breadth. The leaf-scars towards the upper portions of the specimen are rhomboidal. I am inclined to think there is here a case of distorted leaf-scars on the lower part of the fossil, similar to that occurring in Mr. Carruthers' specimen, where, notwithstanding this peculiarity, the fossil is clearly identifiable as *Lepidophloios laricinus*.

With such an imperfectly preserved example as Dr. Williamson's appears to be, any conclusion derived from it is of doubtful value, and though from an examination of his plate one cannot affirm his fossil is a *Lepidophloios*, equally one cannot say it is a *Lepidodendron*.

The figures given by Feistmantel and Dr. Macfarlane are conclusively affirmative that at least some *Halonia* specimens belong to *Lepidophloios*, whereas we have no example which shows in an undoubted manner that any *Halonia* fossil can be referred to *Lepidodendron*. My own opinion is that *Halonia* is exclusively related to *Lepidophloios* as its fruiting branch. Of course, those authors who place *Lepidophloios laricinus*, Sternberg, in *Lepidodendron*, may consistently say that *Halonia* is the fruiting branch of *Lepidodendron*, but I am not aware that any recent writer has followed this classification.

Lepidophloios and *Lepidodendron* I regard as essentially distinct genera. *Lomatophloios* is now united with *Lepidophloios*, hence I understand Dr. Williamson's statement that "The specimen now described is unquestionably not a *Lomatophloios*, but a true *Lepidodendron*," which is equivalent to saying that it is not a *Lepidophloios*, but a *Lepidodendron*.

Sigillaria Menardi, Goldenberg (Flora Saræp. Foss. pl. vii. fig. 1), appears to be referable to *L. laricinus*. The central point of the leaf-scars of this figure is probably the tubercle with which the leaf-supporting pedicels of this plant are frequently provided, as pointed out by Weiss. *U. tumidum*, Carr., the type of which is in the Collection, is, I think, also referable to *L. laricinus*. The leaf-scars are not well preserved on his type, but it probably finds its place here. It is not, at any rate, a *Ulodendron* as defined by Lindley and Hutton, for it shows more than two rows of the larger scars on the circumference of the stem, a third row appearing on the side not shown in Mr. Carruthers' figure.

Halonia tuberculata, Eichwald (Lethæa Rossica, vol. i. p. 148, pl. xi.), is another instructive example as illustrating the affinities of *Halonia*. The core out of this specimen is a typical *Halonia*, the impression *Lepidophloios*. In such examples as these a layer of cortical tissue from between the core and the impression has evidently been removed by decay, after the cortical cylinder had been filled with sediment and the impression of the outer surface of the bark had been imparted to the surrounding matrix. An example in the Collection shows the same conditions—a removable *Halonia* core from a *Lepidophloios* impression.

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[1] Geol. Mag. Vol. X. April, 1873. [2] Phil. Trans. 1883, clxxiv. p. 459. [3] l.c. p. 469.

The plant figured as *Knorria Sellonii*, by Lindley and Hutton (Fossil Flora, vol. ii. pl xcvii.), appears to be a compressed specimen of *Lepidophloios*. I have examined this type in the "Hutton Collection," of which their plate does not give a very correct idea.

I am unable to discover from what evidence Renault has restored his *Lepidophloios*, as represented in his Cours d. Botan. Foss. 1882, pl. xi. fig. 1. It appears to possess the large scars of one genus and the leaf-scars of another.

Horizon.—Coal Measures.

Localities.—*British.* Staffordshire: Ipstones.
Foreign. Bohemia: Radnitz. Silesia: Waldenburg.

Space precludes our giving a fuller notice of this Catalogue. An index and list of works quoted completes the book.

Mr. Kidston has visited numerous localities in search of species, and has added by his exertions nearly 250 specimens to the collection; it is hoped that other gaps which at present exist will ere long be filled by further donations.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—ANNUAL GENERAL MEETING, February 19, 1886.—Prof. T. G. Bonney, D.Sc., F.R.S., President, in the Chair.

The Secretary read the Reports of the Council and of the Library and Museum Committee for the year 1885. In the former the Council stated that they had the pleasure of congratulating the Society upon an improvement in the state of its affairs, both from a financial point of view and on account of an increase in the number of Fellows. The number of Fellows elected during the year was 54, and the total accession amounted to 51; while the losses by death, resignation, etc., amounted to 46, making an increase of five in the number of Fellows. The number of contributing Fellows was increased by 15. The Balance-sheet showed an excess of Income over Expenditure during the year of £347 18*s*. 2*d*. The Council's Report further announced the awards of the various Medals and of the Proceeds of the Donation Funds in the gift of the Society.

In handing the Wollaston Gold Medal to Mr. Warington W. Smyth, F.R.S., for transmission to Prof. A. L. O. Des Cloizeaux, the President addressed him as follows:—

Mr. Warington Smyth,—In the absence, which we much regret, of Prof. Des Cloizeaux, I must request you to transmit to him this Medal.

Geology is the child of two parents,—Mineralogy and Biology. If we look to the latter to bid the dry bones and buried relics of organisms once more live, we appeal to the former to disclose the nature and constitution of the earth's framework whereon they flourished. It is therefore only just that our Society should seek opportunities of acknowledging the aid which we receive from mineralogists; and it would be difficult to find one on whom this Wollaston Medal could be more fitly conferred than on Prof. Des Cloizeaux. To enumerate the papers which he has written would be a formidable task; they numbered 141, so long as fourteen years ago; what, then, must be the present total? I may, however, point, in passing, to his admirable "Manual de Minéralogie," and allude, as more directly bearing on the work of this Society, to his papers on the classification of hyperites and euphotides, on the geysers of Iceland, on the action of heat upon the position of the optic axes in a mineral, and the numerous memoirs on the distinction of minerals by their optical properties, especially those relating to microcline, and to other species of felspar, of the importance of which students of microscopic petrology are daily more sensible. I esteem it a great honour to be the means of carrying into effect the award of the Council by placing in your hands, to be transmitted to Prof. Des Cloizeaux, the Wollaston Medal, founded "to promote researches concerning the mineral structure of the earth."

Mr. Warington W. Smyth, in reply, said:—Mr. President,—It is, Sir, with more than ordinary satisfaction that I am privileged to receive for, and to transmit to, Prof. Des Cloizeaux the Medal founded by Dr. Wollaston. No one can fail to appreciate the appropriateness of this award when we consider the researches into the physical characters of minerals which have contributed so much to the petrological branch of our science, in which you, Sir, have taken so prominent a part. But it is more especially in the wide and successful application of Wollaston's invention of the Reflection Goniometer that Des Cloizeaux has attained so deserved an eminence, following closely upon the steps of Prof. Miller, to whom, in his admiral manual, he pays so high a compliment. The Society will regret to learn that Prof. Des Cloizeaux has been prevented by domestic anxieties from being present to-day.

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Mr. J. Starkie Gardner, F.G.S., and addressed him as follows:—

Mr. Starkie Gardner,—The small number of students and the paucity of memoirs seems to indicate that fossil botany is one of those subjects of which the difficulties repel rather than fascinate the neophyte. If perhaps these are in some respects less formidable in the plant-remains of the earlier Tertiary period, if, in studying them, recent throws some light on fossil botany, yet the practical difficulties of obtaining, developing and preserving specimens are so great that no little ardour and patience are demanded from one who devotes himself to the subject. For years this has been your special work: after thoroughly exploring the flora of the Eocene Tertiaries on the coast of Hampshire and in the Isle of Wight, you are now, and have for some time been, engaged in communicating to us the fruits of your labours through the medium of the Palæontographical Society, thereby earning the thanks of students. Your researches also of late years have been extended to Antrim, Mull, and even Iceland, and their results cannot fail to be of the highest interest in regard to the age of these floras, and their relation to those which occur in the Hampshire district. In recognition of past and in aid of future work, the Council has awarded to you the balance of the Wollaston Fund, which I have much pleasure in handing to you.

Mr. Gardner, in reply, said:—Mr. President,—I beg to return my thanks for the honour the Council have done me in placing the balance of this fund at my disposal. The amount of leisure I am able to command has not permitted me to contribute towards the advancement of geology in this country in anything like the same proportion as my professional brethren; but I think I may fairly claim to yield to none in my devotion to its pursuit. The subject I somewhat unfortunately monopolize is one of such magnitude that, at the best, very many years of such work as I am able to devote to it must elapse before even a first general impression of the composition of our Eocene flora can be published. I am, however, so deeply impressed with the importance of the study that I am prepared to sacrifice much in order that the time required may not be unduly prolonged. I am convinced that in addition to the ordinary botanical, palæontological, and evolutionary interest attaching to it, it will be found to present the solution of many problems as to the former relative positions of land and sea and the climatic changes accompanying their successive redistribution. I need hardly add that I regard the award made me this day as a direct encouragement to persevere in the line of research I have chosen.

The President next presented the Murchison Medal to Mr. William Whitaker, B.A., F.G.S., and addressed him as follows:—

Mr. William Whitaker,—To many members of the Geological Survey of Great

Britain since the date of its constitution we are indebted for work freely done—beyond the sphere of their more strictly professional duties. Its chiefs, from the days of Sir H. De la Beche to the present distinguished Director-General, Dr. A. Geikie, have been among the most valued contributors to our Journal, and have enriched geological literature by their longer writings; while among its other members, few have done more than yourself in following the example of its leaders. On the present occasion I will only allude to the various Memoirs of the Geological Survey, especially that on the London Basin, in which you have taken so large and important a share, and will dwell rather on your contributions to our own Journal and to other publications. Your papers on the western end of the London Basin, and on the Lower London Tertiaries of Kent, deserve to be ranked with the classic memoirs of Prestwich as elucidating the geology of what I may call the Home District; and your last contribution to its deep-seated geology is still too fresh in our memories to need more than a mention. We do not forget your varied and valuable contributions to the GEOLOGICAL MAGAZINE, especially those on the Red Chalk of Norfolk, on the Water-supply from the Chalk, on the formation of the Chesil Bank (written jointly with Mr. Bristow), a paper, as it seems to me, of remarkable suggestiveness, and last, but by no means least, "On Subaerial Denudation," in which, as remarked by the late Mr. C. Darwin, you had "the good fortune to bring conviction to the minds" of your fellow-workers by means of "a single memoir."

We are also greatly indebted to you for your labours in reference to the history of the literature of geology, a task involving not a little labour, which, though of the greatest value to students, is to all unremunerative and would be, to many, exceptionally toilsome. Of this, your care for several years of the Geological Record, and the lists of books and memoirs relating to the geology of various counties in England, are conspicuous instances.

There is a peculiar appropriateness in the award to you of this Medal, founded by Sir Roderick Murchison, one of the illustrious chiefs of your Survey, and I have the greatest pleasure, on behalf the Council of the Geological Society, in placing it in your hands together with the customary grant from the Fund.

Mr. WHITAKER, in reply, said that to workers in science the best reward was the appreciation of their fellow-workers, and of this he had on various occasions received testimonies; but the award of this Medal was the crowning one, knowing, as he well did, the care with which such awards were made. He expressed his interest in the Geological Survey, to which he had for so many years belonged, and in the important work done by his colleagues in that Survey. He had a particular pleasure in receiving this award from the hand of an old friend like the President, whom he thanked most heartily for the very kind and flattering terms employed by him in presenting the Medal. He also thanked the Fellows of the Society present for the cordial manner in which they had received the announcement of the award.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. Clement Reid, F.G.S., the President said:—

Mr. Clement Reid,—The later Pliocene and the Pleistocene deposits of East Anglia offer to geologists a series of problems as difficult as they are attractive. We are indebted to you for much valuable information on the exact distribution and the fossil contents of these varied deposits, which owing to peculiar local circumstances often present exceptional difficulties, and demand exceptionally patient study on the part of the investigators. Your memoir on the Forest Bed of Norfolk is a contribution of especial value to students as affording them fuller and more precise information than could previously be obtained, while the pages of our Journal and of the GEOLOGICAL MAGAZINE testify to the zeal and thoroughness with which you have applied yourself to these and kindred questions. In conferring upon you this award from the Murchison Fund, which I have great pleasure in placing in your hands, the Council of the Geological Society hopes that it may aid you in prosecuting your studies in this department of geology and extending them to localities which could not be visited by you in the discharge of your professional duties as a Member of the Geological Survey of Great Britain.

Mr. CLEMENT REID, in reply, said:—Mr. President,—I have sometimes felt discouraged at the small results of my work. But this welcome and unexpected award by the Council of the Geological Society is a recognition that the work is not considered altogether worthless, and will encourage me still to persevere. Though a large portion of my observations have been made in the course of the Geological

Survey, I have also devoted my leisure time to the study of various questions in Pleistocene and Pliocene Natural History. This award of the Murchison Fund will now enable me to undertake a more thorough examination of many of the less-known deposits.

The President next presented the Lyell Medal to Mr. William Pengelly, F.R.S., F.G.S., and addressed him as follows :—

Mr. Pengelly,—The Council of the Geological Society has awarded you the Lyell Medal and a sum of twenty guineas from the Fund in recognition of your lifelong labours in the cause of geology, and more especially of your investigations in those caverns of the south-west of England by means of which our knowledge of the condition of Britain during the latest epoch of geological history has been so largely augmented. To exhume the contents of a cavern. not only the lair of wild beasts, but also an abode of men in those ages when, to quote the words of the old Greek tragedian,

> "Like tiny ants they dwelt in sunless caves,"[1]

requires the exercise of unwearied patience and, in addition, of extensive knowledge and critical acumen. By the labours of the Committee, of which you were the hands and the eyes, and at least a fair proportion of the compound brain, Mr. MacEnery's long-neglected discovery in Kent's Hole was placed beyond all dispute, and the contents of that cavern, its succession of deposits, its relics of extinct animals, and its tools of stone and bone, denoting more than one stage of civilization, have been made known to the world.

In like way the virgin ground of the Brixham cave was investigated, and its valuable contents have been rendered accessible to students. All this you have done, not as the fruit of secured leisure, but in the intervals of a busy life, of which, in the full sense of the words, time was money; and you began this work at a period when, owing to mistaken prejudices, you incurred no small risk of obloquy and personal loss. Your work at Bovey Tracey and your papers on the later geology of Devonshire and Cornwall are too well known to need more than a passing allusion; the Torquay Museum and the Transactions of the local societies will be a lasting monument of your zeal in stimulating scientific researches in the neighbourhood of your home. There is a peculiar fitness in the award to you of this Medal. a memorial of the fearless and illustrious author of the "Principles of Geology" and of the "Antiquity of Man." I esteem myself exceptionally fortunate in being commissioned to place it in your hands, and being thus enabled to testify my regard for so valued and genial a friend.

Mr. Pengelly, in reply, said that he could not conceal from himself, and did not wish to conceal from the Fellows, the gratification that he felt at receiving this award. He had studied Geology for some fifty years, although he had appeared but little in the rooms of the Geological Society. his publications on geological subjects having been chiefly contributed to those local Societies in whose neighbourhood his researches had been carried on. His gratification at this award compensated for much obloquy, especially as it bore the name of an old and loved friend with whom he had worked much and often. No doubt the founder of the Medal intended that its award should serve not only as a reward for work done, but as a stimulant to further exertion. It came to him so late in the day, however, that he could hardly hope to do very much more; but although he himself might not be urged by it to renewed efforts, the stimulus might act vicariously, as the knowledge that he had received this recognition of such services as he had rendered to science would doubtless get spread abroad in Devonshire, and would probably serve as an incitement to many local workers to persevere in their studies.

In handing the Balance of the Proceeds of the Lyell Donation Fund to Dr. Henry Woodward, F.R.S., F.G.S., for transmission to Mr. D. Mackintosh, F.G.S., the President addressed him as follows :—

Dr. Woodward,—I have much pleasure in placing in your hands, as representing Mr. Mackintosh, the balance of the Lyell Donation Fund awarded to him by the Council of the Geological Society. In him we have a second instance of the way in which, through an untiring zeal for science, the rare intervals of a hard-worked life may bear fruit so largely augmenting the common stock of geological knowledge. There are few problems more interesting than that of the physical condition of our native land during the period commonly designated the Glacial Epoch; but for its solution an exact knowledge of the distribution of erratics and an identification of their points of departure is absolutely necessary. Those who, like myself, have attempted to adjust the rival claims of glacier and floe, of the ice-chariot *versus* the ice-ship, as vehicles of boulder-transport, can hardly speak too highly of the value of the papers on British erratics which he has contributed to our Journal and to other publications. I trust that this award may not only be gratifying to him as a mark of our appreciation, but also help him in continuing his labours in a field where, notwithstanding them, much still remains to be done.

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[1] Æschylus, Prom. Vinct. 491.

Dr. Woodward, in reply, said:—Mr. President,—The intelligence of the decision of the Council has had a most cheering effect on Mr. Mackintosh, and will brighten the remaining years he may have left to him. It is well known to Fellows of this Society what has been the nature of Mr. Mackintosh's work, and what good and careful observations he has made, extending over long years of wandering up and down through England and Wales, and carefully observing wherever he went. I cannot do better than read the following letter from Mr. Mackintosh, which, indeed, is addressed to yourself. He says:—"In thanking you for the honour conferred upon me by the Award of the Lyell Donation Fund, I may mention the fact that 25 years ago I was elected a Fellow of this Society, and that Sir Charles Lyell was one of those who signed my certificate. I am now seventy years of age; this is the second occasion that my work has been so much honoured, for I am proud to be able to state that I was presented with the Kingsley Medal of the Chester Society of Natural Science in 1881."

The President them handed the Award from the Barlow-Jameson Fund to Dr. W. T. Blanford, F.R.S., for transmission to Dr. H. J. Johnston-Lavis, F.G.S., and addressed him as follows:—

Dr. Blanford,—I will ask you to transmit this Award to Mr. Johnston-Lavis. In this country happily the volcanic fires have long ceased to glow, and the earthquake seldom causes more than a transient tremor. It is otherwise on the shores of the Bay of Naples, where again and again during the last eighteen centuries Vesuvius has rained down ruin: and of late years the earthquakes of Ischia have wrought destruction on the works, and desolation in the homes, of men. It is true that these phenomena of the darker side of nature have not been unobserved by the many illustrious men of science to whom Italy has given birth; but "the curse of Babel" has debarred some of us from access to their works. This alone gives an exceptional value to the elaborate studies which Mr. Johnston-Lavis has undertaken of the various eruptive-products of Vesuvius, and of the Ischian earthquakes. There is yet another advantage, that natural phenomena should be studied by men of different nations, diverse training, and varied habits of mind. In recognition of his past labours and in furtherance of future work in the vicinity of Naples, the Council has awarded to him a grant from the Barlow-Jameson Fund, which I have much pleasure in placing in your hands.

Dr. Blanford, in reply, said that the best mode of replying to the kind remarks made by the President would be to read a letter which he had received from Dr. Johnston-Lavis. That gentleman said:—

"It was with a considerable amount of astonishment and pleasure that I received your letter announcing the Grant from the Barlow-Jameson Fund, since the news was so perfectly unexpected. The honour thus paid me for my attempts to clear up some questions in vulcanology and seismology will stimulate me to further follow that line of investigation, with the hope of adding something more to our knowledge of those subjects.

"My professional work at this season prevents me from having the great pleasure of being present in person to receive this mark of esteem from the hands of our President. Will you kindly express my deep gratitude to the Society for so generously conferring such an honour upon me."

The President then read his Anniversary Address, in which, after giving obituary notices of some of the Members lost by the Society during the year 1885, he referred to the principal contributions to geological knowledge which have been made during the past year, both in the publications of the Society and elsewhere in Britain. The remainder of the address was devoted to a discussion of the principles of nomenclature which should be followed in regard to the metamorphic rocks. After describing the nature and relations of the various metamorphic rocks in certain parts of the Alps, Canada, Scotland, etc., the effects of the intrusion of igneous rocks, and the results of pressure in producing changes, both mechanical and chemical, upon rocks originally crystalline, he pointed out that these last could generally be distinguished from anterior foliation, otherwise produced; that many rocks in the metamorphic series appear to have originated in stratified deposits, but that the evidence at present in our possession pointed to the very great antiquity of all these, and to the probability of their having been produced under conditions which have not recurred since the beginning of the Palæozoic period.

The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President*: Prof. J. W. Judd, F.R.S. *Vice-Presidents*: H. Bauerman, Esq.; John Evans, D.C.L., LL.D., F.R.S.; A. Geikie, LL.D., F.R.S.; and J. A. Phillips, Esq., F.R.S. *Secretaries*: W. T. Blanford, LL.D., F.R.S.; and W. H. Hudleston, Esq., M.A., F.R.S. *Foreign Secretary*: Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S. *Council*: H. Bauerman, Esq.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; Thomas Davies, Esq.; Prof. P. Martin Duncan, M.B., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; A. Geikie, LL.D., F.R.S.; Henry Hicks, M.D., F.R.S.; G. J. Hinde, Ph.D.; J. Hopkinson, Esq.; W. H. Hudleston, Esq., M.A., F.R.S.; Prof. T. M'Kenny Hughes, M.A.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W. Judd, F.R.S.; R. Lydekker, Esq., B.A.; J. E. Marr, Esq., M.A.; J. A. Phillips, Esq., F.R.S.; Prof. H. G. Seeley, F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; J. J. H. Teall, Esq., M.A.; W. Topley, Esq.; Prof. T. Wiltshire, M.A., F.L.S.; Henry Woodward, LL.D., F.R.S.

II.—Feb. 24, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On two Rhætic Sections in Warwickshire." By Rev. P. B. Brodie, M.A., F.G.S.

The sections noticed in this paper were (1) one exposed on a railway at Summer Hill, near Binton, between Stratford and Alcester, and (2) one, 13 miles further to the south-east, at Snitterfield, three miles north of Stratford-on-Avon, in excavations for a tunnel connected with a supply of water to that town.

At the first-named locality a bed with insect remains overlies the firestone and *Estheria*-bed, and this is succeeded in descending order by a considerable thickness of black and grey shales with the usual Rhætic fossils. The bone-bed is not exposed.

At the second locality, in borings and shafts, black Rhætic shales were found in three places resting upon a denuded surface of new Red Marl, and covered by between 40 and 50 feet of drift. *Avicula contorta* and other typical fossils were obtained from the shales. In other shafts the Rhætic beds were wanting, so that apparently those met with were merely small portions remaining of a larger mass which had been denuded away.

2. "On the Basement-beds of the Inferior Oolite of Gloucestershire." By E. Witchell, Esq., F.G.S.

The author observed that few papers have appeared lately on this subject in the Quarterly Journal, and admitted that the work done between 1847 and 1860 was of such excellent character that there seemed to be but little left to do in the Cotteswolds. Still he considered, after twenty-five years of experience, that there is room for another paper on the lower beds:—

(1) Because the Pea Grit of Leckhampton is made to include too much.

(2) Because this use of the term has led to confusion.

(3) Because the Pea Grit proper has a greater extension than has hitherto been supposed.

Thus has arisen the mistaken notion that the Oolitic limestone at Frocester and Haresfield Hills is part of the freestone series *above* the Pea Grit. The author proposed to call the beds underlying the Pea Grit the "Lower Limestone," and gave sections at Crickley Hill and Ruscombe, near Stroud, in explanation of his views.

Summarizing the results—(1) The Pea Grit is well developed in the Cheltenham area, thinning towards the south, is no more than from three to five feet thick in the Stroud area, extending as far as Uley Bury, where it occurs as a thin band, having lost its ferruginous aspect. (2) Underlying this are several beds of white Oolitic Limestone, having layers of freestone alternating with layers of shelly detritus, and locally small quartz-pebbles, thickness from 20 to 30 feet. Attention was especially drawn to the contrast which these beds present, both lithologically and palæontologically, to the Pea Grit; and to their poverty in entire organic remains, limited chiefly to a few very small and peculiar Gasteropods. (3) Brown sandy limestones, locally coarse ferruginous gritty beds from 5 to 9 feet, fossiliferous in the lower portion. These are within the *Opalinus*-zone, and repose directly on the Cephalopod-beds.

3. "On the Pliocene Beds of St. Erth." By Percy F. Kendall, Esq., and Robert G. Bell, Esq., F.G.S.

This paper consisted of a description of the beds exposed at St. Erth, a list of the Molluscan fossils identified, and some preliminary considerations of the evidence afforded by the Mollusca, and may be considered a continuation of that by the late Mr. S. V. Wood, read to the Society in November, 1884.

The beds consist of sand and clay dipping to about 5° to N.N.W. The only important fossiliferous bed is a blue clay, and fossils have only been obtained in one spot, though the beds have been traced over an area of about 120 acres. The fossils are well preserved, and with a few unimportant exceptions, are of invertebrate forms, chiefly Mollusca, Polyzoa, Ostracoda, and Foraminifera; remains of Crabs, Cirripedes, Echinoderms, Annelida, Sponges, and even of Holothurians and Tunicata (*e.g. Leptoclinum tenue?*) have been detected.

The list of the Mollusca showed the range of each species in Miocene and Pliocene beds and in the present seas. The authors considered that the fossils agree in age with the middle or lower portion of the Red Crag, but that whilst many species having a southern character are present at St. Erth, and wanting in the Crags of the East coast, the Boreal and Arctic forms found so abundantly in the Crag are absent at St. Erth.

In explanation of this remarkable fact, it is suggested that when the St.-Erth beds were deposited, although the North-Sea area was in direct communication with the Arctic Ocean, the western part of the British Channel was not, that the British Isles were joined to the continent of Europe on one side and to Greenland on the other, the Shetland and Faroe Islands and Iceland being the remnants of the barrier that formerly divided the Atlantic from the Arctic Sea. Evidence is given in support of this view from the present submarine configuration of the North Atlantic. It was also shown to be probable that the St.-Erth area, in Pliocene times, was more directly connected with the Mediterranean than at present, by a marine channel that traversed France.

III.—March 10, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On the Alteration of coarsely spherulitic Rocks." By Grenville A. J. Cole, Esq., F.G.S.

The author stated that the pitchstone of Zwickau, Saxony, contains large spherulites, remarked on by Cotta in 1847, which are devoid of radial structure, and are traversed by the fine lines of flow that characterize the glassy matrix. The centre of each of these has been hollowed out by decomposition along cracks, as may be seen at the ends of the branches into which the cavity divides, and infiltration of chalcedony and calcite has occurred. The lines of flow correspond on opposite sides of this secondary mass, and do not bend round as if the spherule had formed about some calcareous inclusion or about a vesicle. Similar excavation and infiltration have occurred extensively among the coarsely spherulitic layers of the Precambrian rhyolites of Lea Rock, Wrekin, and in these the cracks traversing the rock are seen, under the microscope, as mere lines when passing through the matrix, but widen out at once probably through more ready decomposition along their walls, when they enter spherulitic matter. In the white rock (Silurian rhyolite) of Digoed, near Penmachno, N. Wales, similar alteration has converted the closely set spherulites (often three inches in diameter) into mere shells filled with quartz and chlorite; while a black slate-like decomposition-product, with a hardness of 2·5 and a specific gravity of 2·77, occurs occasionally here, and very frequently in the less coarse but similar rock of Conway Mountain. In the latter place spherulites may be found containing this product in alternate concentric layers. Analysis shows it to be allied to pinite; but the formation in it, when it tends to become crystalline, of microlites of various kinds, opposes its being regarded as a simple mineral. The rock of Digoed itself contains 83 per cent. of silica, the black product only 50 per cent. The great nodular masses of quartz and these contrasted soft, black, cleavable layers form striking features of alteration, especially as the residual spherulitic matter closely resembles the matrix, and may in time become undistinguishable from it. A consideration of the pyromerides of the continent makes it appear probable that they also are altered coarsely spherulitic rhyolites, and the comparisons made by Delesse in 1852 strongly support this view.

2. "Account of a Well-sinking made by the Great Western Railway Company at Swindon." By Horace B. Woodward, Esq., F.G.S. With Lists of Fossils, by E. T. Newton, Esq., F.G.S.

This well-sinking was made under the direction of Captain William Dean, while fossils were collected and notes of the strata were made by Messrs. W. H. Stanier and A. R. Elliott, to whom the authors were greatly indebted. The object of sinking was to seek a supply of water for use in the works at Swindon. The strata proved were as follows:—

	ft.	in.
Made ground	8	0
Kimmeridge Clay	64	1
Corallian Beds	40	1
Oxford Clay and Kellaways Rock	572	9
Cornbrash	18	3
Forest Marble	33	0
	736	2

Unfortunately for the Company, saline waters were met with in the Corallian rocks, and again in the Forest Marble.

Few fossils were obtained from the Kimmeridge and Corallian rocks; but those from the Oxford Clay and Kellaways Rock indicated the upward succession of the Callovian *ornatus-* and *cordatus*-forms of Ammonites. It was shown that at least 44 feet of clays, sands, and sandstones might be assigned to the Kellaways Rock, which should be regarded as an irregular and impersistent basement-bed of the Oxford Clay. Turning to the subject of the saline waters, it was shown from analyses by Mr. F. W. Harris that the Corallian water contained 144 grains per imperial gallon, consisting chiefly of sodium chloride and sodium carbonate. In the Forest-Marble water, which had a temperature of 64°, the saline ingredients amounted to 2131 grains per gallon, consisting chiefly of sodium chloride, calcium chloride, etc.

Attention was then drawn to the occurrence of saline waters in the Jurassic rocks, at Melksham, Holt, Trowbridge, St. Clement's, Oxford, and other localities in the neighbourhood; and also to the occurrence of saline waters in the Coal-measures and older rocks of the Bristol Coal-basin, etc. It was shown that the occurrence of saline waters was not necessarily connected with the proximity of saliferous New Red rocks, and it was suggested that the saline waters at Swindon escaped from a ridge of Palæozoic rocks against which the Lower Jurassic rocks abutted, as they do on the Mendip Hills.

Mr. E. T. Newton said the fossils had been collected with great care by Mr. Stanier and Mr. Elliott, an exact record of depths being kept. He noticed some of the more important species that had been met with and their distribution, especially mentioning that the Ammonites from the Oxford Clay were nearly all from greater depths than 400 feet.

CORRESPONDENCE.

THE GEOLOGICAL AGE OF THE NORTH ATLANTIC OCEAN.—REPLY OF PROFESSOR HULL TO PROFESSOR LE CONTE.

SIR,—I have read with much pleasure Professor Le Conte's views on the question of the "Permanence of Continents and Ocean-Basins"; and especially with reference to the growth of the North American Continent.[1] I am glad that he does not carry his views as far as some geologists on this question. As stated, they are substantially the same as those supported in his "Elements of Geology" (Edit. 1885). It seems to me, however, that Prof. Le Conte scarcely realizes sufficiently what must have been the effect of continued subsidence during the whole of the Palæozoic period in extending the sea-area, and consequently in pushing the adjoining land-area further into that of the present North Atlantic Ocean. In his ideal-section (*Elem.* p. 288) of the Palæozoic rocks from the Primordial downwards to the Carboniferous, which is consistent with his statement that the whole of these rocks in the United States are conformable, Prof. Le Conte makes it clear that were these strata reduced to the original horizontal position, there would be several thousand feet of marine sediments, which must originally have overlapped on the flanks of the lands formed of Archæan rocks. This will, probably, explain to him why in my sketch-map No. 2 I have carried the northern part of the continental border westward so as to cut through Labrador, not in "Primordial times," as he supposes, but in Silurian times, when the land-area was further depressed.[2]

I am gratified to find that on the question of the position of the and and sea areas during Archæan (or Laurentian) times Prof. Le Conte is in accord with myself; on the other hand I fully agree with him as to the immense duration of the "Lost Interval" which elapsed between the Archæan and Primordial eras, and the extent of the denudation of the raised sea-beds over the American and European continents. But, I cannot concur with him in supposing that the small tracts of land which were (at least partially) maintained in the North, as the Laurentian "Nucleus," or along the East of the Appalachians (even with a considerable margin including some now ocean-covered tracts), were sufficient to supply the amount of Palæozoic sediment, which, *when originally deposited* (*i.e.* before denudation), was the measure of the denudation of these tracts themselves. The conformable relations of these beds throughout a vertical depth of several thousands of feet imperatively involves the view of the contemporaneous existence of an extensive continental area, stretching both to the north and east of the present margins of the Silurian strata. Nor, as it appears to me, does Prof. Le Conte recognize sufficiently (if at all) the significance, in reference to this question, of that on which I have laid principal stress in my essay; namely, the increase in thickness of the sedimentary strata towards the north-east and east of the N. American continent, and their attenuation and replacement by limestones in opposite directions. In the case of these sediments they are truncated along their thickest margins; and the fact, which I have pointed out, that the British and European formations exhibit similar phenomena of attenuation and truncation, only in an opposite direction, leads us to a similar conclusion with reference to the position of the derivative lands. Prof. Le Conte admits (p. 100) that the great thickness of Carboniferous strata would require a large land-mass to the east of the Appalachian region; but, he adds, "There is no reason why the eastern land-mass, which sufficed to contribute 30,000 feet of Silurian and Devonian sediments, should not have been sufficient to contribute the much smaller amount of sediments of the Carboniferous period." This, however, allow me to say, is begging the question at issue between us. I maintain in the first place, that the narrow strip of land (comparatively speaking) allowed by Prof. Le Conte was quite insufficient for the production of 30,000 feet of conformable sediments; and secondly, that this continuous accumulation of such sediments must have caused the originating land-mass to recede farther and farther eastwards into the Atlantic area, down to the close of the Carboniferous (or Permian) epoch.

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[1] GEOLOGICAL MAGAZINE, March, 1886, p. 97.

[2] Scient. Trans. Roy. Dublin Soc. vol. iii. new ser. plate vii. p. 319.

Prof. Le Conte is scarcely correct in stating, that in my map, fig. 3, I have completely abolished the Atlantic Ocean by converting it into land during the Carboniferous epoch. As a matter of fact, I have indicated the land as far south as lat. 38°—40°, making it intentionally vague at this line. As will be seen, on referring to the map itself, the main land-areas are represented as occupying the Arctic regions; and there is an interesting fact tending to corroborate the view of the land connection between Europe and America during both Devonian and Carboniferous times which should not be lost sight of, viz. the general resemblance, and partial identity, of the land floras of both regions during these epochs. Altogether it would appear that there is cumulative evidence of the general correctness of the views I have endeavoured to enunciate, whether we have recourse to the organic or physical aspects of the question.

EDWARD HULL.

OBITUARY.

CHARLES WILLIAM PEACH, A.L.S.,

BORN 1800. DIED 1886.

CHARLES W. PEACH, Geologist and Naturalist, was born in 1800 at Wansford in Northamptonshire. His father was a harness-maker. He first went to a dame's school in the village, and at the age of twelve was sent to a school at Folkingham in Lincolnshire, where he remained three years. He was appointed to a post in the Revenue Coastguard in January, 1824, and sent first to Southrepps in Norfolk, and afterwards to Weybourn, Cromer, etc. Here he first commenced the study of Natural History, and began to make a collection. He made the acquaintance of the Rev. J. Layton, then living at Catfield. With this excellent geologist he explored the cliffs and the submerged Forest-bed, and assisted him greatly in collecting the large series of teeth and bones of elephants which are now preserved in the British Museum.

From Norfolk Peach was sent to Lyme Regis and Charmouth in Dorsetshire, and thence into Cornwall, where he worked at the geological formations along the coasts, and found fossils where no fossils had been found before. At the meeting of the British Association held at Plymouth in 1841, he read his first paper entitled "The Organic Fossils of Cornwall." The following year at the Manchester Meeting he read a paper before the Zoological Section, "On the Marine Fauna of the Cornish Coast." Charles Darwin, in his monograph on the *Balanidæ* (Ray Society, 1854, p. 157), quotes Mr. Peach's observations on the exuviation of the integument of the *Balani* on the Cornish coast. He was acknowledged to be one of the most original observers in Geology and Zoology, and was taken by the hand by Murchison, De la Beche, Buckland, Forbes, Daubeny and Agassiz.

While residing at Fowey, he was made an Honorary Member of all the local scientific Societies of the Duchy, and he added many organic remains from the Devonian rocks to the collection of the Royal Geological Society of Cornwall, and this collection seems to have remained as he left it nearly 40 years ago.

One of Peach's most important discoveries was the detecting remains of Pteraspidian fish-shields, in the Lower Devonian Slates of Polperro in Cornwall. These fossils were recognized as fish by Mr. Peach in 1843. In 1851 Prof. Mc'Coy determined the fossil to be a *Sponge*! and named it *Steganodictyum Cornubicum*. Prof. Ferdinand Roemer subsequently determined it to be the bone of a Cuttle-fish, and named it *Archæoteuthis Dunensis* (1855); and in 1868 Prof. Ray Lankester, in a note to the Geological Society, stated that Huxley and Salter, as well as himself, had determined it to be the cephalic plate of a Pteraspidian fish (Quart. Journ. Geol. Soc. 1868, vol. xxiv. p. 546), which he described under the name of *Scaphaspis Cornubicus*. He says, "The merit of first recognizing the fish-nature of these remains belongs to Mr. Peach, who more than twenty years since wrote of them as such" (*op. cit.* p. 547). See also Geol. Mag. 1868, Vol. V. pp. 247–248, and 1869, Vol. VI. pp. 77–78. Mr. Pengelly, writing on the same subject, says:—"Mr. Peach's judgment has received the fullest justification, and we all congratulate him heartily on the fact" (Trans. Devonshire Assoc. for 1868).

Having been transferred from the Coast-guard to the Customs, Peach was removed from Cornwall to the north of Scotland, being stationed first at Peterhead, and afterwards at Wick. It was whilst at the latter place that he made the acquaintance of Robert Dick, the Thurso Baker-Geologist and Botanist, and the account of their friendship and mutual studies is contained in some of the most interesting chapters in Dr. Smiles' "Life of Robert Dick," part of which book is devoted to a biographical sketch of Mr. Peach, to which we are indebted for many of our facts. Here he continued his study of geology and zoology. Whilst travelling round the coast of Caithness in search of wrecks, he made good use of his spare time, hammering the rocks in search of fossil plants with which the dark flagstones of the district abounded. He was the first to find fossils in the limestones of Durness in Sutherland. Obscure organic remains had been detected by Macculloch in the quartz rocks of Sutherland; but they passed out of mind, and their organic nature was stoutly denied by Sedgwick and Murchison. Peach, however, in 1854 brought to light a good series of shells[1] and corals, which demonstrated the limestone containing them to lie on the same geological horizon as some part of the Lower Silurian of other regions. He also found a new fossil fish, which was described in the Decades of the Geological Survey. At the meeting of the British Association at Liverpool, 1854, Peach read a paper on "The Remains of Land Plants and Shells in the Old Red Sandstone of Caithness." In August, 1858, Mr. Peach accompanied Sir R. I. Murchison to the Orkney and Shetland Islands, and finally the two geologists landed at Cape Wrath, and proceeded to visit the Durness Limestone, where all that Peach had already discovered was confirmed by the personal observation of Sir Roderick, who, proceeding to Leeds, laid before the Geological Section of the British Association, "The Results of his Researches among the older rocks of the Scottish Highlands," doing full justice to Mr. Peach's discovery of organic remains of the Lower Silurian age in the Crystalline Limestone of Sutherland, similar to those which occur in the Lower Silurian rocks of North America.

He was a Fellow, and served the office of President of the Royal Physical Society of Edinburgh.

In 1868 Peach was elected an Associate of the Linnæan Society of London.

The "Neill Gold Medal" was awarded to Mr. C. W. Peach in 1874, by the Royal Society of Edinburgh, for the addition of about 20 species of *Echini*, *Medusæ*, and *Sponges* made by him to the known fauna of the British seas.

Though his long and active life had entitled him to rest both from official and scientific work, his vigorous mind and great love for science urged him to further investigations, and in the plant-bearing beds of Edinburgh, Falkirk, and Fife, he made important discoveries, not only of new forms of plant-life, but of materials which increased our knowledge of already described forms.

He died at 30, Haddington Place, Edinburgh, on February 28th, in his 86th year. His son, Mr. B. N. Peach, F.R.S.E., F.G.S., has for many years been attached to the Geological Survey of Scotland, and is the author of several important geological and palæontological memoirs.

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[1] *Maclurea Peachii*, which was named after Mr. Peach, and several other forms.

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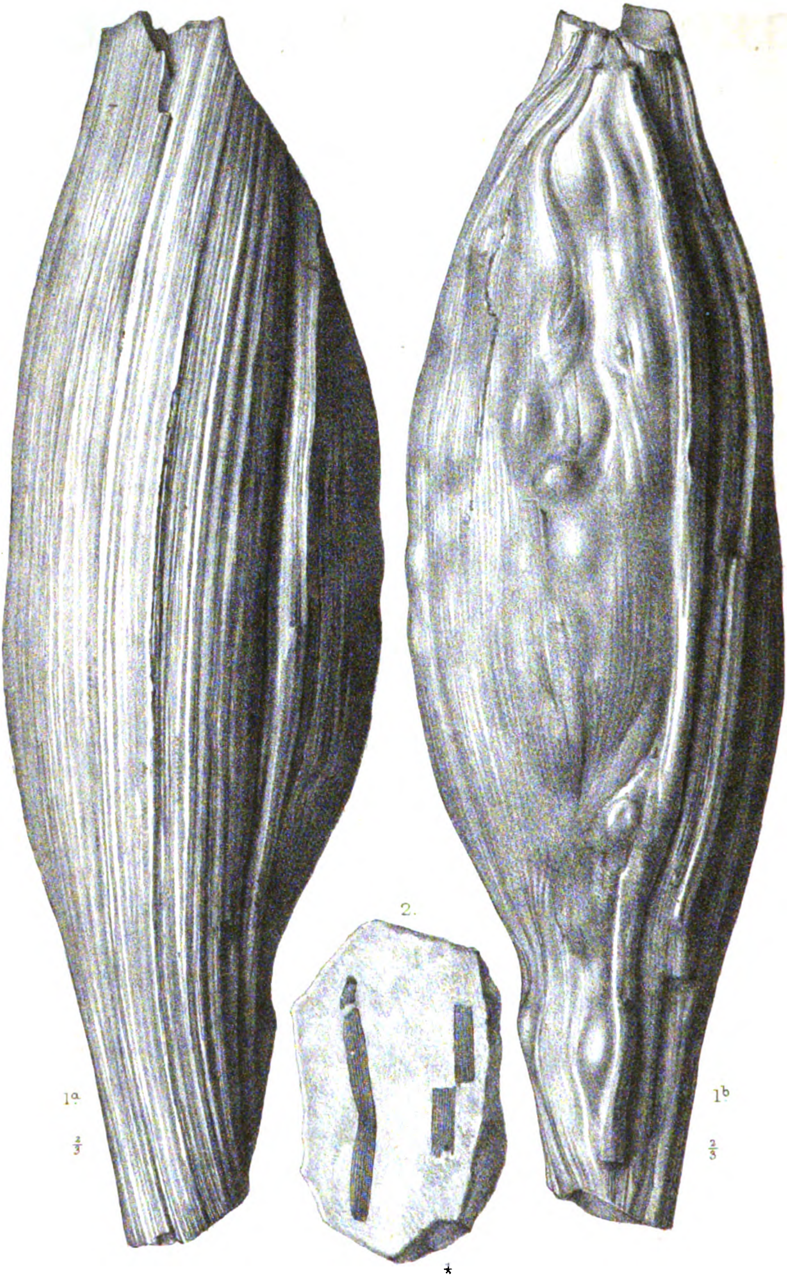

G M Woodward del. et lith. West, Newman & Co imp.

1, Supposed Monocotyledonous fruit; Jurassic, Yorkshire
2, Grass-like leaf from the Purbeck, Swindon.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. V.—MAY, 1886.

ORIGINAL ARTICLES.

I.—On Mesozoic Angiosperms.

By J. Starkie Gardner, F.L.S., F.G.S.

(PLATE V.)

THERE can scarcely at the present time be a problem more interesting than that of the first appearance of Angiosperms, nor one regarding which there is less trustworthy information at the disposal of the geologist. In attempting to bring together a summary of what is known regarding the earlier forms of this most important division of the vegetable kingdom, I make little claim to originality; nor are such criticisms as I may venture upon entitled to the same weight as if put forward by a trained botanist.

It is quite unnecessary to recall the many supposed representatives of Angiosperms that were formerly included in the Palæozoic Floras, for they have long since been dismissed from our lists of fossils and forgotten. Though less fanciful in degree than some of the still earlier geological fallacies, they are no less mythical, and at present the names *Yuccites*, *Palmacites*, *Antholites*, *Poacites*, *Culmites*, etc., are no longer included among the plants of the Coal-measures. Now that *Pothocites* has been shown to be part of a Sigillarian plant, there is in fact no longer any Angiosperm remaining of Palæozoic age. At the same time, it must not be overlooked that Corda described two species of Carboniferous and Permian endogenous wood, while the exhaustive studies of Prof. Williamson, extending over a great number of years, have brought to light the existence of some anomalous woods and other plant-structures from the Coal-measures, in the most perfect preservation, so that it is certainly within the bounds of possibility that we may some day come to a clearer appreciation as to the lines through which Angiosperms were differentiated from the older Cryptogams or Gymnosperms.

There are met with, however, in the Coal-measures, the exceedingly problematical remains of a plant which is claimed in the latest work of Saporta and Marion to be a "pro-Angiosperm," or, in other words, an Angiosperm imperfectly differentiated from a Cryptogamic or Gymnospermic stock. The widely-distributed fossil, known as *Spirangium*, consists of acutely-pointed spindle-shaped bodies, which are believed to be composed of from five to ten linear valves, supposed to envelope a central cavity. These valves usually appear to be spirally twisted, but in some specimens, which seem to be in more perfect preservation, there is no twist visible,[1] so that it is probable that either the spiral arrangement was confined to an inner part of the structure, or that the purpose they had to serve could be equally fulfilled without the twist. They seem to have been seated on a pedicel, and according to Schimper, a number were joined to form a sort of umbel; but in England at least they are generally found detached. Examples were figured in the Transactions of the Geological Society as long since as 1840,[2] under the name of *Carpolithes helicteroides.* No better idea of their enigmatical nature can be given than the bare enumeration of some of the guesses that have been made as to their affinities. They were thought to be allied to *Helicteres*, a genus of *Sterculiaceæ*, by Prestwich and Morris: they are *Palæobromelia* of Ettingshausen, allied to the Pine-apple family; the *Palæoxyris*, of Brongniart, related to *Xyris*,[3] a sedge-like Monocotyledon principally confined to the Tropics; the radicular appendages of *Equisetum* according to Lesquereux; they were named *Sporlederia* by Stickler, who regarded them as Bromeliads; and *Spirangium* by Schimper, who hazards no opinion as to their position in the vegetable kingdom, beyond such as is implied by placing them after the Monocotyledons. Finally, they are claimed to be "pro-Angiospermous" fruits by Saporta and Marion, but it is almost superfluous to say that their affinities remain to this day completely unknown. They are found in all stages, from the Carboniferous up to and including the Wealden, and any discovery tending to shed further light upon them would be of very great importance.[4]

Next in point of age comes a leaf with reticulated venation from the Permian of Russia, and named *Dichoneuron Hookeri*, Sap. It is stated to be of a firm consistence, with a long petiole, slightly dilated at the base and detached naturally from the stem; and an engraving shows it to be bipartite, indented, and lobed and cut laterally into two segments. Saporta and Marion [5] claim that the venation resembles that of *Pistia* (a tropical Duckweed), and that the leaves of the aroideous *Amormophyllum* are similarly bilobed, and suggest the association with it of a spathe-like body from the same formation. Sir Joseph Hooker, however, to whom the specimen was shown, thought that it was probably a cryptogam allied to *Ceratopteris*, a genus of tropical and aquatic Ferns. It is in any case quite obvious that very little importance can be attached to a mere leaf with such undecided characters, when we reflect that leaves greatly resembling each other with not dissimilar venation are common alike to Cryptogams, Gymnosperms, and both divisions of Angiosperms. Another problematic plant, of which the outline at least is perfectly known, is the *Œthophyllum speciosum*, Sch. and Moug., from the Trias of the Vosges. It possessed linear leaves, with fine linear veins without mid-rib, which are decurrent and grouped by threes on a woody and branching stem. The branches are terminated by cylindrical and more or less elongated spikes, whose scales or bracts bore smooth shining seeds in their axils. These spikes were imperfectly articulated at the base and furnished at that point by a ring of paleæ or hairs, and were probably caducous.[1] It has been suggested by several writers that *Œthophyllum* may be allied to the *Typhaceæ*, and though it is by no means even certain that they belong to the Monocotyledons at all, it appears difficult to avoid regarding them with interest as at least possible "pro-angiospermic" types. Certain fruit-spikes from the same formation were named *Echinostachys* by Brongniart.

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[1] There is an admirable specimen showing this condition in the Museum at Owens College.

[2] Prestwich, Geology of Coalbrook Dale, Geol. Trans. vol. v. part iii. plate 38, fig. 12, and explanation by Prof. Morris.

[3] A view recently upheld by Nathorst.

[4] The species described as *Palæospathe* by Unger from the Carboniferous and Permian, may possibly also belong here. A list of them is given in Schimper, Pal. végétale, vol. ii. p. 505.

[5] Evolution des Phanérogams, vol. i. p. 231.

Synchronous with the last, and also common to the Jurassics, are narrow ribbon-like leaves known as *Yuccites*, Sch. and Moug., five species of which are described by Zigno.[2] They are broad or narrow linear leaves, with entire margin, and without mid-rib, with fine longitudinal veins united by transverse veinlets and sessile or amplexicaul base. As stated by Schimper,[3] "It is useless to remark that these fossils may proceed from very different types, and perhaps without real analogy with the living type to which we compare them." They most resemble the leaves of *Dracæna* or *Fourcroya*.

In the Rhætic we meet for the first time with the remarkable organism known as *Williamsonia*, a fossil familiar to us from its not uncommon occurrence in the Oolite of Yorkshire. It appears to have been figured first as a flower[4] in Bird's Yorkshire, pl. ii. fig. 6, associated with *Zamites*, and later by Mantell in 1844, Medals of Creation, vol. i. p. 161, as the fruit of *Zamites lanceolata*, in consequence of a conjecture by Lindley that the supposed petals were scales and the stamen and pistil the fractured axis. It was first described by Prof. Williamson in a communication to the Linnean Society,[5] in 1868, and was named after the Professor by Carruthers; but at that time it was considered that the Cycadean foliage associated with it, and known as *Zamites gigas*, might very probably belong to the same plant. The fructification is very rarely attached to stems with spirally arranged leaves, and to such stems and the fruit the genus is now restricted. It seems no longer possible to regard it as even an utterly abnormal Cycad, and the question therefore arises as to whether Saporta and Marion have sufficient grounds for ranking it among their "pro-Angiosperms." Mr. Carruthers and Prof. Williamson appear uncertain as to which section of the vegetable kingdom it should enrich, while Dr. Nathorst advances the rather untenable proposal to place it in *Balanophoraceæ*, a small natural order of succulent leaf-less, parasitic Dicotyledons, to which *Rafflesia* belongs, while Newberry appears to regard them as possible Composites.[1]

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[1] Schimper and Mougeot, Monogr. d. pl. foss. du Grès bigarré, p. 39, pl. xix. xx.

[2] Flora foss. forma. oolithicæ, i.-iv.

[3] Pal. végétale, vol. ii. p. 427.

[4] A closed bud is apparently figured as a nut, pl. iii. fig. 7.

[5] Linn. Trans. p. 663, pls. 52 and 53.

The branches of *Williamsonia gigas*, Carr., are stout, densely clothed, with remarkably thick and short sheathing leaves, amplexicaul, loosely imbricated, dorsally keeled or convex, inferiorly canaliculate, and with lanceolate, stiff, and even spinous apex. They are coriaceous, smooth, with entire margins and parallel veins, united by a delicate network of oblique veinlets only visible with a lens. Many of these stems are terminated by more or less developed globose involucres, composed of at least one whorl of converging linear bracts, bent inwards so as to form a chamber, which is sometimes empty, showing the basal scar from which the interior organ had become detached. The largest of these involucres are formed of several rows of bracts enveloping a peculiar gourd-shaped body or axis invested with a dense covering of compressed long narrow cells, which Saporta regards as an investing mass of filaments and anthers, such as that covering the spadix of *Typha*. Prof. Williamson calls this a cortical layer, but has inferred that it possibly bore antheridial organs: Saporta adds that these fell away after the pollen was shed, leaving the axis bare. Saporta asserts, and Williamson thinks it not improbable, that this involucre represents the male organ of the plant.

Associated with them are found verticils of incurved bracts united at their bases into a cup-shaped organism, which Williamson on the one hand is confident have never been found attached to any other, but which Saporta maintains are sometimes present in the interior moulds, in which condition all the English specimens are found, adhering to the gourd-shaped axis which he says it surmounted. The important collection of Mr. Yates is now in the Jardin des Plantes, and I have not had the opportunity of examining it since I became interested in the subject; but on the other hand Professor Williamson certainly possesses a specimen in which each bract is furnished with a pair of oblong depressions, which are clearly not accidental markings as Saporta would believe, and are obviously adapted for bearing a pair of ovules. The remarkable thing is that none of the other numerous specimens, so far as I know, in our public museums show any such marks. Moreover, the gourd-shaped axis is sometimes prolonged into a peculiar point which can be most readily described as in shape like a light-house, and which finds no place in Saporta's restoration.[2]

The rest of the description of *Williamsonia* is taken wholly from

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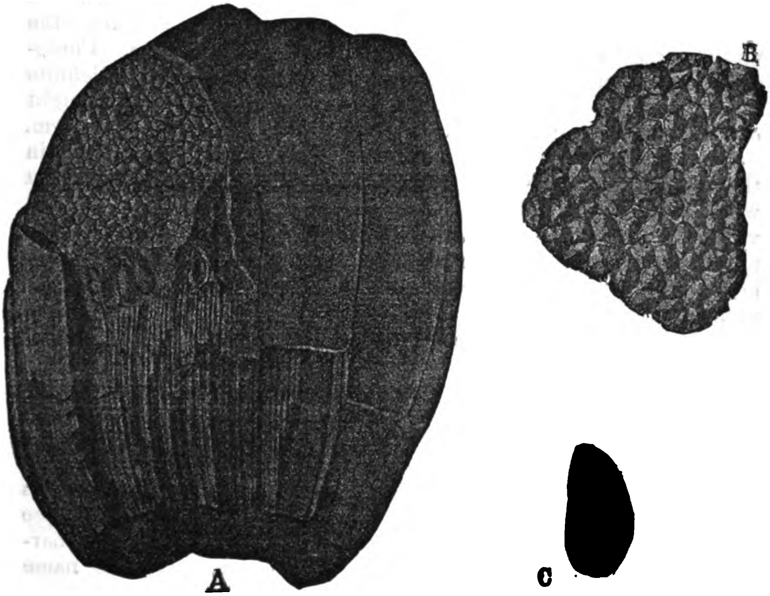
[1] Dr. Newberry describes a number of helianthoid flowers which he calls *Palæanthus*, from the Cretaceous Amboy Clays, which are three to four inches in diameter and greatly resemble *Williamsonia*. He remarks that though "so much like flowers of Compositæ, we are not yet warranted in asserting that such is their character," Bull. Torrey Botanical Club, vol. xiii. p. 37, 1886.

[2] The cup is described by Saporta and Marion, Evolution des Phanérog. vol. i. p. 240, as a large cup or bell-shaped expansion with fringed or lobed margin, composed of coriaceous and fibrous tissue, comparable to the spongy apex of the fleshy spadix of *Amorphophallus*, and more remotely with the tuft of leaves crowning the Pine-apple.

Saporta and Marion,[1] as the specimens preserved in museums in this country do not appear to reveal the characters claimed by these distinguished French authors. They say that in addition to the male involucres are others, smaller, less regularly globose, generally empty, with a broad cicatrix at the base, corresponding to the insertion of an organ which has evidently become detached in a natural manner. Complete specimens, however, show a globular receptacle or spadix, shrunk as if empty and surrounded by the bracts forming the involucre. Sometimes this involucre appears to have been detached entire, but more often the globular spadix with the inner row only of bracts was disarticulated. The surface of the spadix itself is areolate, the compartments irregularly polygonal, either grouped in rosettes of five or six round central points, which appear to be stigma of ripe pistils, or with these latter more irregularly interspersed among them. The areolæ are presumably barren carpels. An Indian specimen shows the female spadix to have possessed a fibrous covering which was shed in a single piece. A



A. Fruiting organ of *Williamsonia Morieri*, Sap., naturally shed. The specimen is preserved as carbonate of iron. Some of the bracts of the involucre remain, and beneath the areolæ an accident has exposed some of the ripe seeds in their natural position. The specimen, magnified twice, is from the Oxfordian of Vaches-Noires. *B.* Areolæ formed of carpels grouped together and compressed, the central points being the scars of the stigmas. *C.* A seed greatly magnified. After Saporta and Marion.

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[1] Saporta has an exhaustive treatise on the subject in the press, which will be superbly illustrated, in which he intends to demonstrate the absolute identity of *Williamsonia* with *Podocarya*.

very perfect specimen of *Williamsonia Morieri*, beautifully preserved in carbonate of lime, is from the Oxfordian of Calvados. In this species only the upper half of the spadix, which is ovate instead of globose, is covered with areolæ, in consequence of the fibres of which the areolate covering is formed being directed upwards obliquely, instead of at right angles to the axis. This disposition has fortunately enabled some of the ovules to be uncovered, and shows that they are situated in the interior of the rosettes in which the areolæ are arranged, each one corresponding to an entire rosette. Thus most of the pistils were unfertilized, supposing there were as many pistils as areolæ, and several of them became subsequently united into syncarps. Each areola when magnified is polygonal and convex, with the facets culminating in a small button, an arrangement exactly similar to that of *Pandanus fragrans.* The ovules or seeds were attached by the base, which was rounded, while the other end was more pointed.

The spadix was not a true inflorescence, or spike composed of a number of flowers on one axis, as in the true *Spadicifloræ*, but a branch with every leaf metamorphosed into carpels, and thus the morphological equivalent of the gynœcium of the *Magnolia.* Consequently it represents a single flower composed of an indefinite number of unisexual elements, a structure of a kind that might *a priori* have been expected to occur in an early type of pro-Angiosperm.

Small buds, as well as the more mature organisms, are met with in the Yorkshire Oolites. Other and distinct species have been met with in the Oolites of India,[1] France, and some of the Baltic provinces, in some of these cases apart from any associated Cycadean remains.[2] An organism found by Griffiths in the Grey Chalk between Dover and Folkestone, in which the coaly substance of the plant is preserved, was forwarded by me to Saporta, who pronounced it without hesitation to be a *Williamsonia.* It would be interesting to have this determination confirmed, as it strengthens the evidence already in existence, tending to show that no great change took place in the Flora of the British area, from the Jurassic to the Cretaceous, inclusive.[3]

The oldest definite Monocotyledons however are the well-marked Pandanaceous fruits from the Oolites, which therefore take rank as the earliest known Angiosperms. One of the most distinct of these was figured by Buckland in 1836 from the Inferior Oolite of Charmouth,[4] to which, at R. Brown's suggestion, he gave the name

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[1] Feistmantel lays great stress on their occurrence in the rocks of the Rajmahal group as supporting his view that they are of Jurassic age. There are two species besides the one considered identical with the Yorkshire *W. gigas*, Pal. Indica, Flora of Kach, p. 73, 1876.

[2] Williamson, On some Anomalous Oolitic and Palæozoic Forms of Vegetation, Proc. Roy. Institution of Great Britain, Feb. 16, 1883.

[3] Saporta writes to me under date April 2nd, 1886, regarding this fossil:—"Je crois bien que c'est un véritable *Williamsonia*, mais écrasé et méconnaissable et je n'ose pas le décrire dans l'état où il est, ne sachant même si ce ne serait pas quelque type spécial." It appears, however, that it is to be figured in a forthcoming work.

[4] Geol. and Min. vol. i. p. 504; vol. ii. p. 101. Unger, Gen. et Spec. Plant. Foss. p. 327.

Podocarya. Carruthers redescribed it[1] as of "the size of a large orange, and composed of an indefinite number of cells, each containing, near the surface, a single longish seed, about the size of a grain of rice. The cells were separated from the spadix by long fibrous footstalks, and were surmounted by hexagonal tubercles, in the centre of which could be seen the remains of a stigma." The resemblance of this fruit to that of *Williamsonia* when deprived of its involucre should not be overlooked.[2] Another Pandanaceous fruit from the Great Oolite of Kingsthorpe, near Northampton, is named *Kaidacarpum* by Carruthers and is thus described (p. 155, *op. cit.*):[3]—

"The fruit consists of a thick spadix,—not so thick, however, in proportion to the drupes as in *Bryantia butyrophora*, Webb. The drupes leave the spadix at a right angle about one-third from the apex, those above have an ascending and those below a descending direction, increasing as it reaches the fruit-stalk, which is seen in the fossil, and shown in the drawing. This arrangement is precisely that of *Sussea conoidea*, Gaud. The drupes are rhomboidal at the base, spreading out laterally towards the apex, where their form is a broad compressed rhomb two or three times longer than it is broad. The cell containing the seed is near the base of the fruit, leaving only a short pedicle or being really sessile, as in the recent species with single-seeded drupes. Each drupe contains a single seed; and although the whole structure is replaced by calcite, yet the details are so beautifully shown that the connection of the seed by an internal unilateral placenta adnate to the whole length of the cell is in many cases obvious. The seed is ovoid and compressed and the cicatrix at its base, by which it was attached to the placenta, can be detected." A comparison of the fossil with *Sussea conoidea*, Gaud., places it beyond doubt, in the author's opinion, "that it is a true *Pandanaceous* fruit." Another less perfectly preserved species is in the Woodwardian Museum from the Potton Sands of Cambridgeshire, and figured by Lindley and Hutton, but it is certainly a derived fossil, and of Jurassic age. Another is recorded from the Upper Greensand of Wiltshire. It was originally figured by Lindley and Hutton as *Strobilites Bucklandi*, in their Fossil Flora, vol. ii. pl. 129, published in 1833–35, from a drawing by Miss E. Benett, made for Dr. Buckland, without the least clue as to age or locality in the descriptive letterpress. In Miss Benett's "Catalogue of the Organic Remains of Wiltshire," published in 1831, the only fossil referred to, which could possibly be the *Strobilites* in question, is a *Cycadeoidea?* from the Portland Beds, under the heading "Woods," p. 9. In the first edition of Morris's Catalogue, 1843, it is put down as from "Gr. S. Wilts," which cannot mean either Lower or Upper Greensand, the abbreviations for which are "L. G. S.," and "U. G. S." but which looks like a misprint for "Gr. O.," the sign for Great Oolite. In the second edition Morris, 1854, it appears as from "U. G. S. Wiltshire." The question is whether in correcting the printer's error of the first edition, due care to ascertain the facts *de novo* was used. The circumstances are such as to leave the age of the fossil in considerable doubt.

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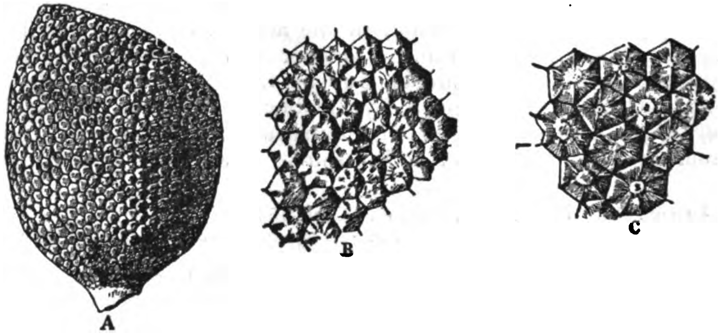
[1] GEOL. MAG. Vol. V. April, 1868, Pl. IX. pp. 153-156.

[2] See note *ante*. I was not in the least aware of Saporta's conclusion when this was written.

[3] The mode of preservation is important, and is stated to be as follows:—"The matrix in which it is preserved is an amorphous cream-coloured limestone, which has abounded in Molluscan remains, but the shells have been removed, and the spaces they occupied, as well as the other larger cavities in the rock, are lined with or entirely filled up by crystallized calcite. The fruit also is only a cast in the same material, of the cavity which originally contained it. The fine white mud had insinuated itself into every crack and opening of the fruit, and filled the decayed interior of the upper portion of the drupes. The walls of the seed cavity and the seeds themselves, as well as the outer membrane of the drupes, resisted decay until the matrix was somewhat compacted. These hard portions at length decayed, but the insoluble carbon remained as a black amorphous substance, giving an external coloured coating to the crystallized carbonate of lime, which in the end filled the cavity, preserving in the most perfect manner the form of the fruit, and even some of the minute details as to the relation of the different parts." GEOL. MAG. *l.c.*

Part of a similar fruit is also described by Heer from the Cretaceous of Patoot in Greenland.

A not dissimilar but still smaller fruit has been found in the Coralline Oolite and the Kimmeridge Clay in France. These, named *Goniolina*, are small ovoid, aggregated fruits, like those of *Pandanus*, borne on a naked, cylindrical and relatively slender petiole. The heads of the very numerous fruits are arranged in spirals and regular, closely pressed together and barely a millimètre across. They are of hexagonal shape, and six keels extend from the angles and meet in a raised point in the centre. The interior axis is cylindrical, and impressed with scars made by the bases of the fruits, completing its likeness to *Pandanus*.



Goniolina. Fruiting organ. From the Jurassic, in the Paris Museum. After Saporta and Marion.

The *Aroïdes Stutterdi*, from the Great Oolite,[1] must, it appears on the other hand, be expunged from the list of fossil plants, for Dr. Woodward has well-nigh conclusive evidence proving that this calcareous organism is part of an Echinoderm, *Apiocrinus* (*Millericrinus*) *Prattii*. *Poteriocrinus* and *Platycrinus* are furnished with singular prolongations emerging from the calyx, known as the "proboscis" (really the efferent orifice), which exactly resemble externally the spadices of large Aroideous flowers.[1] Though the calyx and "proboscis" have not been found united in this particular species, the fact that the supposed spadix is calcareous, and is far from uncommon in a purely marine formation, renders it in the highest degree improbable that it could be any portion of the flower of an Aroid such as *Xanthosoma.* These singular crinoid probosces were however not known when the determination was made. It is a remarkable fact, that up to the present, there are no fossil representatives of the *Aroideæ* described, save a single fragment from the Tertiary of Eriz, in Switzerland, named *Aronites dubius* by Heer, a determination thought by Schimper to be doubtful. Our Eocene Flora, however, contains several important representatives of the group.

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[1] See paper by W. Carruthers, F.R.S., GEOL. MAG. 1867, Vol. IV.

Several quite distinct types of Monocotyledons have been recorded from the Lias, the principal of these being *Bambusium liasinum,* Heer,[2] a leaf very similar to those mentioned as *Yuccites* without mid-rib and with two to four fine veins alternating with every more decided one. Stems supposed to have been solid and cylindrical and jointed are said to have been found associated with the leaves. Some other fragments described as *Cyperites protogæus,* Heer, supposed to be a species of *Cyperaceæ,* and *Zosterites tenuistriatus,* Heer, possess no characters whatever on which any opinion should have been expressed, and must certainly be expunged. The stems of *Endogenites erosa,* so common in the Wealden and Neocomian, are now known to be Cycadeous, and it is probable that the *Dracæna*-like stems from Tilgate Forest and elsewhere, so often referred to by Mantell, are referable to the same group. There are also many Jurassic-Cretaceous fruits which may quite conceivably prove to be angiospermous, and which deserve careful study.

The remarkably fine stem I have figured is in the possession of Prof. Williamson, who states that it is the *Calamites Beanii* of Bunbury.[3] Sir Charles, however, remarks on the tumid articulations, "the stem being much thicker in those parts than in the intermediate spaces," so that he must have had specimens of *Equisetum columnare,* which occur abundantly in the same beds, in his mind. In speaking of it Prof. Williamson observes that "so far as external appearances are concerned, it more closely resembles the stem of one of the arborescent *Gramineæ.* But such appearances have very little Taxonomic value. Nevertheless, the plant stands out in prominent distinctness from amongst the Ferns, Cycads, and Conifers that grew around it, forcibly suggesting the idea of an arborescent Monocotyledon; and if such has been its character, its position amongst these older Oolites would make it, if not the earliest, one of the earliest representatives of the Monocolytedonous group."[1] The stem is somewhat compressed, and the piece preserved is evidently from near the base, the three joints of which it is composed diminishing rapidly, the first measuring 2 inches, the second 1¾, the third 1½ inches in height. The diameter of the middle joint is about 5 inches, but its crushed condition has no doubt considerably added to the width, which was probably nearer 3½ inches before compression. The exterior has a smooth and silky look, with fine longitudinal veins. The nodes are depressed, about 1/16 of an inch wide, and bordered by slight collars or thickenings. The stem seems to have been hollow, though it may perhaps have been solid like the sugar-cane; it has an altogether different texture to that of *Calamites* or *Equisetum*. There are unfortunately no other organs in these beds which can be even tentatively united with it.

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[1] Although this conclusion seems highly probable, it must be borne in mind that *at present* we know of *no Secondary* stalked crinoid with a "proboscis" like *Poteriocrinus* or *Platycrinus.* All the forms with this appendage being of Palæozoic age.—H. W.

[2] Heer, Flora Helvetiæ, p. 138, pl. 55.

[3] Quart. Journ. Geol. Soc. vol. vii. p. 189, *C. giganteus,* Bean MS.

Supposed Monocotyledonous stem from the Jurassic of Yorkshire.

[Owing to the unfortunate loss of the wood engraving in transit by rail, the figure of Prof. Williamson's specimen had at the last moment to be omitted, but will be inserted in the June Number.—EDIT. GEOL. MAG.]

The specimen figured, Plate V. Fig. 1, *a* and *b*, is now in the Woodwardian Museum, and is also stated to have come from the Yorkshire Oolites. As in all fossil vegetables from these deposits, there is no internal structure preserved, and we are therefore only able to deal with the exterior. This appears to represent on one side a ropy ligneous stem, slightly twisted, and with a half-lunar section. On the other side is a thick, closely adherent spathe, rather smoother than the stem, but furrowed, very thick and leathery, acutely pointed at the top, and narrowed and amplexicaul at the base. The spathe or pod is 9 inches long, 2½ broad, and 1½ inches deep in its greatest diameter. There is a slight swelling near the base, with two or three projections, as if there were ovules under the spathe, then a contraction, and then the main swelling with apparent traces of more ovules under it, especially towards the apex. The seeds or fruits would appear to be oval and about half an inch in length. At the base, where the spathe joins the stem, its substance is seen to be 1/16th of an inch in thickness, and it is an inch across; the stem itself being 1¼ inches wide, rather compressed and squarish. It increases upward with the spathe, becoming more crescentic in section, and again diminishes as the spathe commences to taper to a point. Though the transverse section reveals no structure, it shows clearly the demarcation between spathe and fruit and the stem.

It forcibly reminds us of some palm spathes and fruits, and if it should prove to be merely concretionary, it would certainly be a case of most extraordinary mimicry. Such a view seems however, quite out of the question, and we cannot help regarding it as a monocotyledonous fruit of some kind, and greatly regret that its precise locality and horizon cannot be fixed with greater precision.

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[1] On some Anomalous Oolitic and Palæozoic Forms of Vegetation, Royal Instituion, Feb. 16, 1883.

The supposed *Najadita*, on the other hand, is quite certainly no Angiosperm, but a Cryptogam.

These remains, which must obviously have belonged to a fresh-water plant, occur in some profusion in the fissile limestone at the base of the Lias or top of the Rhætics in the neighbourhood of Bristol.[1] The precise beds are called by the Rev. Mr. Brodie "Estheria beds," from the quantity of *Estheria Brodieana*, var. (T. R. Jones), which they contain, while the valves of a species of *Cyclas* are also very abundant with them.[2] The plant remains were determined by Prof. Buckman to belong to the Monocotyledons, and named by him *Najadita* on account of the relationship which he believed they bore to the family of *Najas* or Pond-weeds, and were described and figured in the Quarterly Journal of the Geological Society, 1850, vol. vi. p. 415. The supposed early appearance of this group of Monocotyledons has excited considerable interest, and has frequently been quoted and referred to in works on palæontology and botany. Wishing to re-examine them, I communicated with the Rev. P. B. Brodie, in whose cabinet many of the original specimens are preserved, with the result that a number of them were placed at my disposal.

My first examination convinced me that far from being Monocotyledons, they were cellular Cryptogams of some kind, the supposed rectangular venation being nothing more than the cell walls of the tissue forming the leaf-blades. I next took them to Manchester, where Prof. Williamson kindly looked at them, and without a moment's hesitation pronounced them to be the remains of cellular plants. Since then Mr. Carruthers has examined them, when Mr. Ridley, who has charge of the Monocotyledons, and Mr. Murray, in whose care the Cryptogamic section of the British Museum Herbarium is placed, were also invited to express their opinions, the result being that all these botanists agreed in regarding them as Cryptogams resembling *Fontinalis* in habit. They in fact bear the strongest possible resemblance to these fresh-water mosses, and without wishing to place them definitely in the genus *Fontinalis*, it does appear to me to be useless to seek further among existing plants for their affinities. This group of fresh-water mosses has not previously been included in any fossil flora, and it would indicate a temperate climate, thus corroborating the evidence of the insects associated with it, and that the water was limpid, with a feeble current. I am most pleased to be able to state that Mr. Brodie quite concurs in the transfer of his specimens to the aquatic mosses.[3]

The *Lilia*, *Bensonia*, and other supposed Monocotyledons and

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[1] Q.J.G.S. vol. vi. p. 415, 1850.

[2] Mr. Brodie informs me that he regards them as a junction bed between the two formations.

[3] Mr. Brodie has since sent me a capsule from these beds, which appears to belong to the same moss.

Dicotyledons of Buckman[1] seem to be either Cycadaceous or too indistinct to be determinable, and no importance whatever can be attached to their supposed Angiospermous affinities.

Among many specimens lent me by Mr. Brodie, however, is one undoubtedly Monocotyledonous fragment from the Purbeck of Swindon (Plate V. Fig. 2), three millimètres wide, with nine parallel equal longitudinal veins. It has a rush or grass-like appearance, but may possibly belong to an aquatic plant.

The records of some of the supposed early Angiosperms may have escaped me, but some have purposely not been included in this notice, because they are not deserving of mention.

No new types come in during the Lower Cretaceous, and our knowledge of the Angiosperms of this period remains in a most imperfect state. There are still jointed stems and occasional fragments of sword-like leaves, and the important *Dracæna*-like *Eolirion*, of Schenk. I have found rolled pellets of palm-like wood in the Gault at Folkestone, and, as already stated, an organism in the Grey Chalk which Saporta pronounced to be a *Williamsonia.* The most remarkable thing is that not the smallest trace of an Angiosperm has been found in the Wealden deposits, though these appear to have been pre-eminently likely to have preserved such, had they existed. A host of Dicotyledons as well as many of the principal families of Monocotyledons, come in with the Upper Cretaceous, but the relative ages of the beds in which they occur are by no means satisfactorily determined, and, as Floras, they are rather to be grouped with those of the Tertiaries than those of the Wealden, Neocomian and Gault.

The mystery in which the early development of Angiosperms is still shrouded is the more inexplicable, since the presence of a flower-sucking moth in the Solenhofen beds is a well-ascertained fact. From a remark made by Prof. Marsh, at Aberdeen, there is some hope that welcome revelations regarding American Jurassic Angiosperms may reach us ere long. In the meantime I refrain from encumbering this communication with any of the obvious speculations that have occurred to me, and probably to others, as possible explanations of their extreme rarity in præ-Cretaceous deposits. The evidence tends to show that Monocotyledons (?) of some sort existed as far back as the Trias, possessing leaves of the most primitive type, such as we now meet with in *Yucca*, *Dracæna*, etc., and that during the Jurassics decided Monocotyledons, which can be placed in the *Pandanaceæ*, and others with jointed stems like *Gramineæ*, flourished side by side with more problematical plants such as *Williamsonia.* Little more than this can yet be said, though Saporta and Marion bring forward an array of arguments and inferences wherewith to build up a family tree,[2] which if not quite carrying conviction, are certainly highly suggestive, and deserve the most careful consideration.

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[1] Murchison and Buckman, Outline of the Geology of Cheltenham, 1845.

[2] Evolution des Phanérogames, Saporta and Marion.

II.—ON THE PALÆONTOLOGY OF THE SELACHIAN GENUS *NOTIDANUS*, CUVIER.

By A. SMITH WOODWARD, F.G.S.,
of the British Museum (Natural History).

(PLATE VI.)

AMONG the Selachians of the existing fauna, there are none of greater interest and higher morphological importance than *Notidanus*, *Cestracion*, and the recently-discovered *Chlamydoselachus* from Japanese seas. These are the solitary survivors of once flourishing types, whose immediate congeners are only known to Biological science through the fragmentary remains preserved in the geological record; and the value of the archaic features they present is even further enhanced by the slight information already acquired regarding the geological distribution of their numerous extinct allies.

Hitherto, however, there appears to have been no attempt at a systematic treatment of the Palæontology of the first of these genera, although the Cestraciont and Cladodont types have received a large share of attention. I therefore propose to offer a short account of the present state of knowledge of this subject—summarizing the results of previous research, making known a few interesting fossils that have not yet been described, and adding some general remarks on the extinct congeners of the Notidanidæ, so far as they can be determined from the evidence of detached teeth.

Briefly reviewing the main anatomical features of the living *Notidanus*, in the first place, there are several peculiarities especially worthy of note. The skull is remarkable from its close approach to the amphistylic type of Professor Huxley.[1] Unlike all other living Selachians, the upper element of the hyoid arch is extremely slender and takes no part in the support of the pterygo-quadrate and mandibular cartilages; but this is compensated for by a distinct facette upon the otic process which articulates with the post-orbital process of the chondrocranium.[2] The mandibular and hyoid arches thus most nearly retain their primitive condition, and there is also only a very slight advance upon this stage in *Cestracion*:[3] in this genus, the pterygo-quadrate articulates with the pre-orbital region of the chondrocranium, and the "hyomandibular" is only just becoming worthy of that name. These characters are so important, when taken in conjunction with others exhibited by the same types, that in dividing the Selachii into four great suborders, Prof. Theodore

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[1] T. H. Huxley, "On *Ceratodus Forsteri*, with Observations on the Classification of Fishes," Proc. Zool. Soc. 1876, pp. 40–45.

[2] See excellent figures by C. Gegenbaur, "Das Kopfskelet der Selachier" (1872), plate x.

[3] T. H. Huxley, *loc. cit.* p. 42, fig. 8.

Gill[1] regards the Notidanidæ and the Cestraciontidæ as the sole existing representatives of the first two.

Notidanus is also remarkable for the persistence of the notochord. One section of the genus (*Hexanchus*) exhibits this gelatinous rod merely subdivided by transverse membranous septa, while the other (*Heptanchus*) has annular cartilages in the sheath which only show traces of calcification in the region of the tail.[2]

As regards fins, the genus under consideration differs from other Sharks (except *Chlamydoselachus*) in possessing only a single dorsal, without spine, which is placed far back, partly opposite the anal. The latter is well marked off from the caudal. The structure of these locomotory appendages in *Notidanus* is also interesting, but there is much difference of opinion as to the conclusions to be drawn from them. Prof. Huxley has given reasons[3] for regarding the pectorals as of a more primitive type than those of other living Selachians and as most nearly related to the so-called "archipterygium" of *Ceratodus;* while Prof. Mivart[4] is led to dissent entirely from this interpretation, and to look upon it as nothing more than "an ingenious speculation." The latter has also shown (*loc. cit.*) how the basal cartilages of the dorsal and ventral fins, and, to a less extent, those of the anal, have become fused together into a nearly continuous mass,—a fact of considerable significance if, as seems probable, the basals were a parallel series of thin cartilaginous bars in the earliest forms of fin.

Another curious feature of *Notidanus* consists in its possession of more than five gill-openings besides the spiracle, and in this peculiarity it differs from all other living Sharks except the *Chlamydoselachus.* Some of the species have six of these openings and others seven; and most ichthyologists prefer to regard each of these types as constituting a distinct genus, the first named being termed *Hexanchus*, and the second *Heptanchus* or *Heptranchias.* Dr. Günther,[5] however, is inclined to admit no such separation, and as it is quite impossible for palæontological purposes, it cannot be adopted here.

But the points to which the palæontologist is naturally led to devote most minute attention are those relating to the harder structures capable of preservation in the fossil state. And it fortunately happens that in the living Notidanidæ there are very decided differences in the teeth of the various species. It is also true, on the other hand, that the dentition of each individual exhibits a certain variability in its components according to their situation in the jaw; but a careful comparison of actual specimens, descriptions, and figures, appears to reveal a few characters that are practically constant, and suggests the possibility of at least determining detached *side* teeth.

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[1] In Jordan and Gilbert's "Synopsis of the Fishes of North America," Bull. U. S. National Museum, No. 16 (1883), p. 967.

[2] See detailed descriptions of C. Hasse, "Das Natürliche System der Elasmobranchier—Besonderer Theil" (1882), pp. 39–52, pls. vi. vii.

[3] *Loc. cit.* p. 50.

[4] St. G. Mivart, "Notes on the Fins of Elasmobranchs," Trans. Zool. Soc. vol. x. (1879), p. 477.

[5] A. Günther, "Catalogue of Fishes Brit. Mus." vol. viii. (1870), pp. 397–399.

In a typical species like *N. indicus* the upper teeth on and near to the junction of the pterygo-quadrate cartilages have some resemblance to very thick, depressed teeth of *Lamna*, without lateral denticles, but placed upon a fibrous base undivided into radicles. The side teeth exhibit one or two distinct denticles or denticulations in front of the principal cone, and an increasing number of small cones behind this, the latter being larger in proportion to the main cone the more remote is the tooth from the front of the jaw. The mandible exhibits a single symphysial tooth, with three or four laterally directed toothlets on each side, but no median cone; and then follow six nearly similar comb-shaped teeth, both to the right and the left. In these, the principal cone is serrated anteriorly, and the hindermost tooth—as in the upper jaw—shows the principal cone least predominant. At the back of both jaws, there are also minute teeth—diminutive knife-edges of enamel, each upon the characteristic form of base.

Besides the widely distributed species whose dentition has just been described, Dr. Günther recognizes three others in his British Museum Cat. Fishes, and about three more have subsequently been determined in America.[1] Ichthyologists thus distinguish about seven living forms of *Notidanus*, and on referring to their published diagnoses, it appears that at least three features in their dentition are specially looked upon as of specific value. These are (i.) the presence or absence of a median tooth, and the presence or absence of a median cone in such a lower tooth; (ii.) the relative prominence of the principal cone in the mandibular side teeth—whether inconspicuous, proportionately stout, or notably elongated; and (iii.) the character of the denticulations in front of the principal cone of the lower teeth. It is obvious that, of these distinctive features, only the two latter are available to the palæontologist, except on rare occasions; but it is satisfactory to find that the upper teeth apparently exhibit the same specific modifications as the lower—*e.g.* a stout or long cone in the one corresponding to a stout or long cone in the other—and it is thus possible to restore the dentition of some of the extinct types with a considerable approach to accuracy.

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[1] Jordan and Gilbert, "Fishes of N. America," *loc. cit.*, p. 62: and S. Garman, Bull. Essex Institute, vol. xvi. (1884), pp. 56, 57.

Of fossil Notidanidæ, no undoubted traces have hitherto been recorded from beds beneath the Middle Oolite. Münster,[1] it is true, mentions a small tooth from the Lias as belonging to *Notidanus*, but no figure is given, and there is not sufficient proof of the accuracy of the determination. Oppel[2] also makes known another tooth from the Upper Lias of Swabia, which he ventures to name specifically *N. Amalthei*, though evidently recognizing the slenderness of the grounds for this procedure; his figure shows nothing beyond a laterally-compressed cone, and neither this nor the description suffices to distinguish it from the tooth of a large *Oxygnathus*. It is further interesting to note that Tate and Blake[3] have recorded Oppel's species from the Middle Lias of Whitby, and this determination is equally unreliable: the original fossil is said to be preserved in the Whitby Museum, but Mr. Martin Simpson has failed to discover it during a search he has kindly undertaken in response to my inquiries, and I am also indebted to Professor Blake for a reference to his note-books, which likewise afford no definite particulars.

The Oxfordian *N. contrarius* and *N. Münsteri* are thus the earliest species of the genus at present described, and with these we commence an enumeration of the different specific types that appear to be distinguishable upon the evidence of detached teeth.

1. N. CONTRARIUS, Münster.

1843. *N. contrarius*, Graf von Münster, "Beitr. zur Petrefaktenkunde," pt. vi. p. 54, pl. ii. fig. 3.

Founded upon a broken tooth from the Lower Oxfordian[4] of Rabenstein, Bavaria. The fossil exhibits two small diverging cones, with a denticle behind, but is much too fragmentary for specific determination, and does not appear to have been recorded since Münster's original description.

2. N. MÜNSTERI, Agassiz.

1843. *N. Münsteri*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 222, pl. 27, figs. 2, 3.

A species founded by Agassiz upon some detached teeth from the Oxfordian (Weiss Jura γ, Quenstedt) of Streitberg, Franconia, and of Randen, Schaffhausen, Switzerland. The type specimen figured exhibits a principal cone destitute of anterior serrations and relatively large both in breadth and height; this is followed by three well-marked secondary cones, closely approximated, and rapidly decreasing in size, and the crown terminates in a small denticulation.

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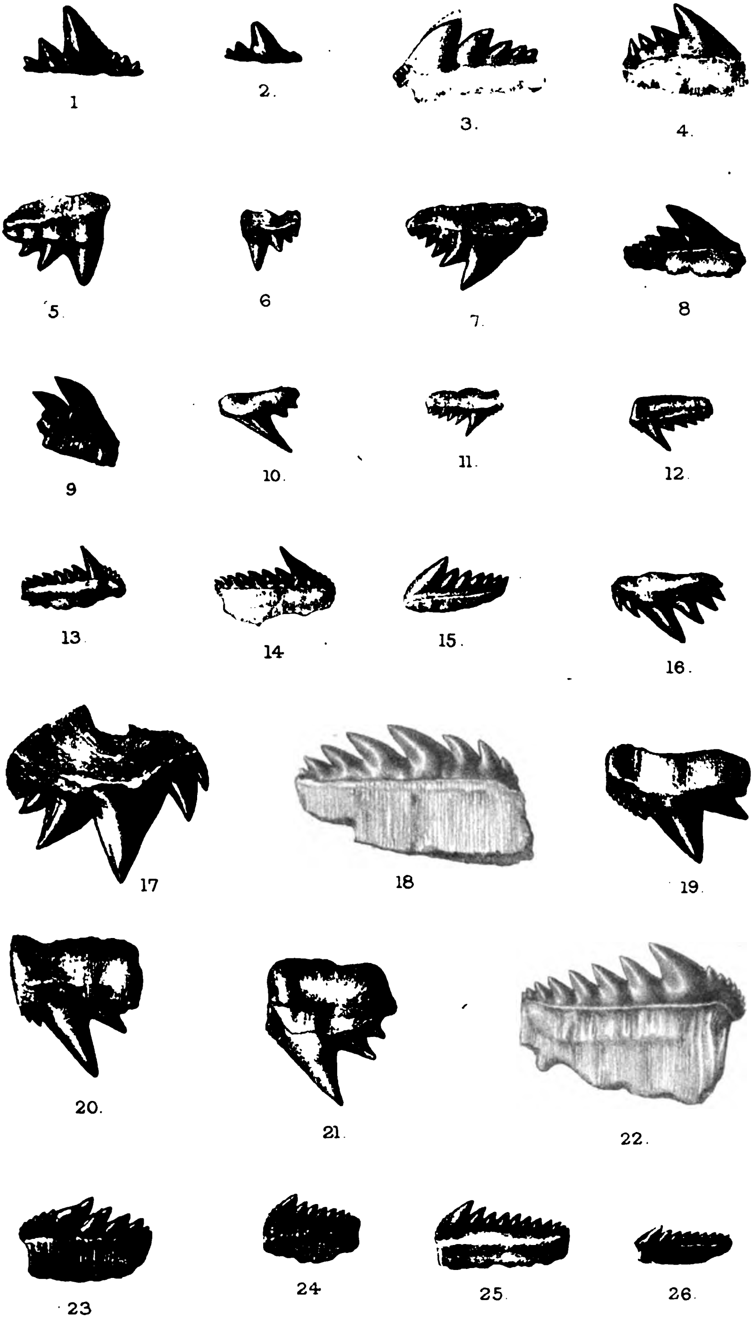
[1] Münster, "Beiträge zur Petrefaktenkunde," pt. vi. (1843), p. 55.

[2] A. Oppel, "Der mittlere Lias Schwabens," Württb. Jahresh. vol. x. (1854), p. 62, pl. i. fig. 1.

[3] Tate and Blake, "The Yorkshire Lias" (1876), p. 256.

[4] This and the other Jurassic horizons have been kindly supplied by Mr. Etheridge.



G M Woodward del et lith
West, Newman & C° imp

Fossil Notidanidæ.

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There seems to be no undoubted reference to teeth of this type since Agassiz' original description, though the name is mentioned in several lists of Continental Jurassic fossils. The specimens from Schnaitheim figured by Quenstedt as *N. Münsteri* are almost certainly referable to a distinct form next to be considered.

3. N. EXIMIUS, Wagner. Pl. VI. Figs. 3—5.

1849. *N. Münsteri*, Beyrich and Frischmann, Zeitschr. Deutsch. Geol. Gesell. vol. i. p. 436, pl. vi.
1852. ,, ,, F. A. Quenstedt, "Handb. Petr." p. 167, pl. 13, fig. 4.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 662, pl 96, figs. 33, 34.
1861. *N. eximius*, A. Wagner, Abh. k. bayer. Akad. d. Wiss. cl. ix. vol. ix. pp. 292–296, pl. iv. fig. 2.

The Lithographic Stone (Lower Kimmeridgian) of Bavaria is the only deposit that has hitherto yielded remains of *Notidanus* other than detached teeth. But from this fine-grained rock at least three comparatively perfect fishes have been described, in addition to one other fragment of the caudal extremity. Of these, the finest specimen was figured by Beyrich and Frischmann, *loc. cit.*, in 1849, and the subsequent studies of Dr. Andreas Wagner resulted in its being separated from all other known species under the name of *N. eximius.*

The important fossil just referred to was obtained from the quarries of Eichstädt, and is complete with the exception of the tip of the tail: it indicates an original length of about nine feet, and exhibits a very definite outline, owing to the presence of plentifully scattered shagreen granules in the skin. The head is rounded and obtuse in front, and a considerable number of teeth are exhibited in the region of the mouth. The pectoral fins are evidently larger than the ventrals, and the anal is small compared with the dorsal; the latter is almost entirely in advance of the anal, although appearances may be deceptive owing to pressure during fossilization. But the most remarkable character displayed in this specimen is the presence of well-marked annular cartilages in the sheath of the notochord. These have been carefully studied by Dr. Hasse,[1] of Breslau, who has shown that they agree in microscopical structure with those of the living *Heptanchus*; and this Kimmeridgian form is thus the only fossil species hitherto discovered that it has been possible to refer to the correct subgenus. The vertebral rings in the caudal region are further apart than in the more anterior portions of the body.

The two other specimens of *Notidanus* from the Lithographic Stone are of small size, not exceeding 4½ inches in length, and are regarded by Wagner as probably the young of the species under consideration. No figures have been published, but a plaster cast of one of these immature fishes is exhibited in the British Museum.

A group of the teeth of *N. eximius* are figured by Beyrich and Frischmann, and Wagner also represents a solitary example. The drawings of the Eichstädt fossil, however, do not appear to illustrate the variation of the dentition in different parts of the mouth, nor do the authors offer any particular observations upon this point. In the ordinary lateral teeth, the principal cone is destitute of serrations on its anterior border, and is followed by three (or sometimes four) much smaller cones. These teeth chiefly differ from *N. Münsteri* in the wider interspaces between the successive cones. They are also somewhat larger, and the apex of each cone occasionally exhibits a slightly hooked appearance.

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[1] C. Hasse, "Natürl. Syst. Elasm.—Besond. Theil," pp. 51, 52, pl. vii. figs. 23–25.

Other teeth of the type just described are met with in the Upper Corallian beds of Schnaitheim, Würtemberg, and were originally figured by Quenstedt (*loc. cit.*) under the name of *N. Münsteri*. Wagner makes a brief allusion to these at the end of his description of *N. eximius*, and hints that they may possibly belong to his newly determined species. The National Collection contains a good series of specimens from the same deposit, which appear to leave no doubt of the correctness of this identification, and three of these form the subjects of Figs. 3–5. The teeth exhibit considerable variation in size—from one to two centimetres in length—and this may be due not only to age, but also to differences corresponding to the various parts of the jaw. All, however, are characterized by wider interspaces between the cones than is the case in *N. Münsteri*. In teeth that are probably from the front region of the mandible (Figs. 3, 4), the principal cone is relatively longer and less oblique than in those further back; while in anterior teeth of the upper jaw, the principal cone is still more prominent and placed erect upon the base. Fig. 5 represents one of the latter type, and the original of fig. 34, pl. 96, in Quenstedt's "Jura," is probably another from nearly the same situation. Of lower teeth, the other illustrations of Quenstedt are evidently characteristic examples, and Fig. 3 is a drawing of the largest tooth in the British Museum Collection; this specimen—like two others, Nos. 22489 and P. 4708—is remarkable on account of the oblique abrasion of the apex of the principal cone, which appears to have been produced during the life of the animal. The same figure also shows a slight crimping at the lower part of the anterior edge of the tooth; and fig. 33, pl. 96, of Quenstedt's "Jura," likewise exhibits this feature upon a greater extent of the border, but there is no definite denticulation.

It is interesting to add that Wagner further records a single tooth of *N. eximius* from Daiting, and another from the Lithographic Stone of Nusplingen, Swabia.

The upper tooth shown in Fig. 6 was also obtained from the Schnaitheim beds, but it appears scarcely referable to *N. eximius*, and must remain at present specifically undetermined.

4. N. WAGNERI, Agassiz, sp.

1843. *Aellopos Wagneri*, L. Agassiz, Rech. Poiss. Foss." vol. iii. p. 233.
1861. *Notidanus Wagneri*, A. Wagner, Abh. k. bayer. Akad. d. Wiss. cl. ix. vol. ix. pp. 296–299.

In the volume of the "Neues Jahrbuch" for 1836, p. 581, Count Münster briefly recorded a Selachian fossil from the Kelheim Lithographic Stone under the name of *Aellopos elongatus*. It exhibited nothing more than the hinder region of the body, and its affinities were thus somewhat problematical, but the distinguished palæontologist just mentioned felt justified in regarding it as the type not only of a new species, but also of a new genus. Some years later, when preparing his classical work on Fossil Fishes, Agassiz confirmed Münster's original determination, and founded a second species of *Aellopos*—termed *A. Wagneri*—upon another specimen preserved in the Munich Museum. This likewise exhibited only the hinder region of the body, but the great relative size of what was then considered to be the second dorsal fin, and the distinctly calcified vertebral rings, were quite sufficient to separate it from all fossil sharks at that time known. No figures were published, however, and Agassiz' short notice embodied all available information until 1861, when Dr. Andreas Wagner was engaged in investigating the fish-fauna of the Solenhofen Stone, and succeeded in elucidating the problematical fossil by a reference to the magnificent specimen of *Notidanus eximius*, figured by Beyrich and Frischmann. His researches led to the conclusion that Münster's *A. elongatus* was really a *Squatina* (or an allied genus), and that Agassiz' *A. Wagneri* might be referred with equal certainty to the genus *Notidanus*. The considerable dimensions of the supposed "second" dorsal fin were thus no longer remarkable, and the comparatively advanced condition of the vertebral column was recognized as quite similar to that of the complete specimen just quoted. Some minor differences are sufficient to distinguish *N. Wagneri* from *N. eximius*, and among others, may be mentioned the relatively greater length of the dorsal fin: the vertebræ are also longer, and wide interspaces between them do not begin to appear before the middle of the tail, whereas in *N. eximius* this character is obvious quite at its commencement.

5. N. INTERMEDIUS, Wagner.

1861. *N. intermedius*, A. Wagner, *loc. cit.* p. 299, pl. iv. fig. 3.

A species founded upon a single tooth from the Lithographic Stone of Mühlheim, near Solenhofen, and characterized by the large size of the denticulations in front of the principal cone, which is thus placed not far in advance of the middle of the tooth. Behind the principal cone are five smaller ones.

As Wagner observes, this determination is merely provisional, for the dentition of *N. Wagneri* is at present wholly unknown, and the form of tooth in question may eventually prove to belong to the latter species.

6. N. HÜGELIÆ, Münster.

1843. *N. Hügeliæ*, Graf von Münster, "Beiträge zur Petrefaktenkunde," pt. vi. p. 54, pl. i. fig. 5.
1852. ,, ,, (?) F. A. Quenstedt, "Handbuch der Petrefaktenkunde," p. 167, pl. 13, figs. 5, 6.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 519.

This species was founded by Münster upon a broken tooth from the Corallian of Gammelshausen, near Boll, Würtemberg. The specimen exhibited a large principal cone (without anterior serrations) followed by two small cones of about one-third the size of the first.

The originals of the figures in Quenstedt's "Handbuch" are very much smaller than the type specimen, and are characterized by the presence of anterior serrations; it is doubtful, indeed, whether they are truly referable to this form.

7. N. SERRATUS, Fraas. Pl. VI. Fig. 7.

1855. *N. serratus*, O. Fraas, Württemb. Jahresh. vol. ix. p. 98.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 784, pl. 96, fig. 44.

This species was originally named by Fraas, but does not appear to have been completely defined before the publication of Quenstedt's work on the Jura. The last-mentioned palæontologist records a group of about 14 teeth, naturally associated, and figures one of the most typical forms. This, as a Jurassic type, is remarkable on account of the number of distinct cones that make up its crown, and the prominence of the sharp denticulations on the front edge of the principal cone; the latter is comparatively broad and long, and is succeeded by seven minor cones, of which the anterior is very much the largest. The species occurs in the Corallian of Nusplingen, Swabia.

A detached specimen in the British Museum (No. 35667), obtained by the late Mr. Bean from the Oxford Clay of Scarborough, agrees so closely with the tooth of this species figured by Quenstedt that it cannot be separated on present evidence. The fossil in question is shown of the natural size in Fig. 7, and is in an almost complete state of preservation. The principal cone of the crown is relatively very large, and is succeeded by five secondary cones, while at its base in front there occur three closely approximated denticles, the first being of considerable size. Of the secondary cones, the most anterior is directed sharply backwards and makes a wide angle with the posterior edge of the principal cone; it is nearly a third larger than that immediately following, and the remaining three are quite small. The base-line of the crown is arched, and the lower border of the root has a somewhat crimped appearance. This is evidently a tooth of the upper jaw, and the respects in which it differs from Quenstedt's figure are precisely those in which the upper teeth of living species differ from the lower.

8. N. DAVIESII, sp. nov. Pl. VI. Fig. 8.

1871. *Hybodus polyprion*, J. Phillips, "Geology of Oxford," p. 305, pl. xii. fig. 18.

The scarcity of remains of *Notidanus* in the Jurassic rocks of Britain appears somewhat remarkable when it is remembered how frequently they have been recorded on the Continent: and in addition to the Scarborough tooth already described, I have only succeeded in meeting with two other specimens.[1] These were erroneously referred to *Hybodus* by Professor Phillips, *op. cit.*, and they have been kindly pointed out to me by Mr. William Davies, who recognized their true affinities some years ago when identifying fossil vertebrata in the Oxford Museum; I am also indebted to the kindness of Professor Prestwich for the opportunity of studying and publishing a further notice of the original teeth.

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[1] Besides others already named, I have also to thank the following friends and correspondents who have kindly assisted me in the search for Jurassic Notidanidæ:—Mr. E. T. Newton, of Jermyn Street; Mr. T. Roberts, of the Woodwardian Museum, Cambridge; Mr. H. M. Platnauer, of the York Museum; Mr. H. J. Moule, of the Dorset County Museum; and Mr. H. E. Quilter, of Leicester.

The specimens in question were obtained from the Oxford Clay of St. Clement's, near Oxford, and as they cannot be safely identified with any form at present known, I propose to apply to the most satisfactory tooth (Fig. 8) the provisional name of *N. Daviesii*: the second fossil (Fig. 9) may possibly be a variety of the same species, but this is at present uncertain. In the type specimen shown in Fig. 8, the principal cone is relatively large, both in breadth and height, and is destitute of serrations on its anterior border. This is followed by four rapidly diminishing secondary cones, and the crown terminates in a minute denticulation. The apices and edges of all the cones are remarkably sharp, and the base is short and thick compared with that of the majority of later species. The second tooth (Fig. 9) has a very peculiar form, and consists merely of two backwardly curved cusps, though other small ones may have been broken away behind. The lower part of the anterior edge of the principal cone is crimped, and the enamelled sides of the crown exhibit vertical wrinkles suggestive of those of *Hybodus*.

N. Daviesii appears to approach *N. Münsteri* more closely than any other, but it is easily distinguished from this species by the different relative proportions of the principal and secondary cones.

9. N. MICRODON, Agassiz. Pl. VI. Figs. 10—15.

1822. Tooth of *Squalus?* G. A. Mantell, "Fossils of South Downs," p. 227, pl. xxxii. fig. 22.
1843. *N. microdon*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 221, pl. 27, fig. 1, pl. 36, figs. 1, 2.
1843? ,, ,, H. B. Geinitz, "Schichten und Petrefakt. d. sächsisch.-böhm. Kreidegeb." p. 38, pl. ix. fig. 2.
1846. ,, ,, A. E. Reuss, "Verstein. d. böhm. Kreideform." pt. ii. p. 98, pl. xlii. fig. 8.
1850. ,, ,, F. Dixon, "Geol. and Foss. Sussex," pl. xxx. fig. 30.
1878. ,, ,, A. Fritsch, "Rept. u. Fische d. böhm. Kreideformation," p. 12 (woodcut).

Almost all the teeth of *Notidanus* met with in the Upper Cretaceous formations are referable to a single widely-spread species, *N. microdon*. This is a small form with a total number of five to nine distinct cones in its side teeth, each of these being slender and sharply pointed, and the principal cone usually much elongated compared with the remainder: there are also well-marked denticulations on the front edge of the crown.

On examining a large series of specimens, such as that available for study in the British Museum, considerable variations are at once apparent; but there are scarcely any discrepancies in size, and the presence of intermediate forms renders it quite impossible to recognize more than a single specific type. Some (Fig. 10) are obviously from the front of the upper jaw, and consist only of a single large cone, with one or two small denticles behind; while the short teeth, with prominent principal cone and 4—5 secondary cones (*e.g.* Figs.

11, 12) may be referred with almost equal certainty to situations in the upper jaw somewhat further back. The elongated teeth, which belong to the sides of the lower jaw—and perhaps partly to the upper—usually have the principal cone relatively prominent (Figs. 13—15), though in one or two examples such is not the case. The anterior serrations are mostly fine and numerous, but in a few instances (of upper teeth) they are reduced in number and increased in size.

Of British Cretaceous strata, the various divisions of the Chalk appear to yield the most abundant remains of *N. microdon*, although the Cambridge Greensand also affords a considerable number. The National Collection comprises specimens from Maidstone, Burham, and Charing in Kent; Lewes and other localities in Sussex; Guildford in Surrey; and Swaffham and Norwich in Norfolk.

10. N. LANCEOLATUS, sp. nov. Pl. VI. Fig. 16.

In the Egerton Collection of the British Museum there is a single upper tooth of *Notidanus* (P. 1227) from the Gault, which it appears impossible to identify with any species hitherto described. It is much larger than the corresponding teeth of *N. microdon*, and as its most conspicuous feature consists in the comparatively long and narrow form of the cones, I propose to distinguish this type of tooth by the provisional name of *N. lanceolatus*. The principal cone is relatively prominent, and is preceded by two very long denticles: there are three secondary cones, and the crown terminates in a minute denticulation. The great development of the anterior denticles renders it likely that the lower teeth were somewhat similar to those of *N. pectinatus*, Ag., but the latter is a much smaller species.

11. N. PECTINATUS, Agassiz.

1843. *N. pectinatus*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 221, pl. 36, fig. 3.

A species founded upon a tooth from the Chalk, about the size of *N. microdon*, but especially differing from that form in the conversion of the anterior serrations of the crown into a series of distinct denticles. This type of tooth appears to be extremely rare, and I have not seen any examples.

12. N. DENTATUS, sp. nov. Pl. VI. Figs. 17, 18.

Among the Selachian remains in a collection of New Zealand fossils sent by Dr. Hector to the British Museum in 1876, there are two teeth from the Cretaceous of Amuri Bluff which are undoubtedly referable to the genus *Notidanus*. In several respects they differ from one another to a considerable extent, but an acquaintance with the dentition of living Notidanidæ can leave no doubt that they belong to a single specific type, and that the one is an upper tooth, while the other formed part of the mandibular series.

The lower tooth, which is shown of the natural size in Fig. 18, exhibits three small denticles in front of the principal cone, the first being the largest and having a recurved apex, the second slightly smaller with straight but backwardly-directed point, and the third very much more minute. Behind the principal cone, which is scarcely more robust than that immediately following, there are ranged three other cones, of gradually diminishing size; and posterior to these a minute denticulation is visible.

In the upper tooth (Fig. 17) the principal cone appears more definitely contrasted with the others. In front there are two distinct denticles, the first being three times the size of the second, and the principal cone itself is placed almost vertically with respect to the base-line of the crown, although its anterior edge has a much less abrupt slope than the posterior. Behind this, there are three other cones rapidly decreasing in dimensions; the first, somewhat inclined backwards and three-fourths the size of the principal cone; the second, backwardly directed at a corresponding angle, but only about one-third as large as the first; and the third, a minute, broad acuminate denticle. Though now imperfectly shown, the base-line of the crown was obviously arched, and the remains of the root indicate the usual configuration and robust proportions of an upper tooth.

On considering this assemblage of characters, the substitution of distinct denticles for the ordinary serrations on the anterior edge of the principal cone in the lower tooth, is obviously the most striking feature; and hence it is proposed to distinguish the present modification under the specific name of *N. dentatus*. The only other fossil *Notidanus* that exhibits this peculiarity is the very rare *N. pectinatus* from the English Chalk, but this is a much smaller species, and differs in possessing a longer series of cones behind the principal. Among existing forms, however, one appears to be remarkable for its possession of the very same character.[1] This is the little *N. pectorosus* from the seas off the Patagonian coast, and Mr. Garman's description[2] of the lower tooth of this form agrees almost precisely with the particulars given above; he states that each tooth "has one to two small, followed by four moderate-sized, cusps, the anterior of the four being little if any longer than the other three; and, in cases, there is also a small cusp on the posterior portion of the base." Indeed, in the absence of figures, *N. dentatus* can only be distinguished from *N. pectorosus* by the presence of one more anterior denticle in its teeth, and by its relatively gigantic size—for the Patagonian species is only 16 inches in total length.

If subsequent researches tend to substantiate the latter statement, the fact becomes of unusual interest, since it was from the same deposit at Amuri Bluff that Mr. E. T. Newton, a few years ago,[3] made known a tooth of *Callorhynchus*, differing only in minor points from *C. antarcticus* of the present southern seas. This living Chimæroid ranges through the same ichthyological province as Mr. Garman's new species of *Notidanus*, and the association of two extinct allies in a formation said to be of Cretaceous age in New Zealand is a very remarkable circumstance.[1]

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[1] The lower teeth of *N. cinereus* also exhibit some approach to this character.

[2] S. Garman, "A species of *Heptranchias* supposed to be new," Bull. Essex Institute, vol. xvi. (1884), pp. 56, 57.

[3] E. T. Newton, "On Two Chimæroid Jaws from the Lower Greensand of New Zealand," Q. J. Geol. Soc. vol. xxxii. (1876), pp. 329, 330, pl. xxi. figs. 6—9.

13. N. SERRATISSIMUS, Agassiz. Plate VI. Figs. 23–26.

1766. *Dens Squali*, G. Brander, "Fossilia Hantoniensia," fig. 111.
1843. *N. serratissimus*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 222, pl. 36, figs. 4, 5.
1870. „ „ F. Römer, "Geologie von Oberschlesien," p. 379, pl. 48, fig. 1.

This species was founded upon two teeth from the London Clay of Sheppey, said to be preserved in the collection of Dr. Bowerbank, but not now recognizable among the specimens acquired by the British Museum. The teeth are comparatively small—the largest I have examined not attaining a length of two centimetres—and the total number of cones appears to vary from five to ten, according to the situation in the mouth. The principal cone is only slightly longer than the first of those immediately following, but it is somewhat more robust and has its anterior edge much produced forwards and strongly indented with a series of regular serrations throughout half its length. The apices of all the cones are more or less blunt.

Fig. 23 represents a typical tooth of this species, such as was known to Agassiz. I have not succeeded in satisfactorily determining whether it appertains to the upper or the lower jaw; but in addition to this form the London Clay also yields a number of more elongated teeth, which are undoubtedly referable to the mandibular series. An adult specimen is preserved in the Museum of Practical Geology, and there are several immature examples in the British Museum. Three of the latter are shown in Figs. 24–26, and, except in size, they only differ from the adult in being either destitute of anterior serrations or exhibiting very delicate traces of them.

In England, *N. serratissimus* appears to be almost exclusively confined to the London Clay, rarely occurring in the Middle Eocenes of Barton and Bracklesham. On the Continent, however, Dr. Römer has described (*loc. cit.*) a similar tooth from the Lower Miocene of Zabrze, Silesia.

14. N. PRIMIGENIUS, Agassiz. Pl. VI. Figs. 19–22.

1843. *N. primigenius*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 218, pl. 27, figs. 4–8, 13–17.
1843. *N. recurvus*, L. Agassiz, *ibid.* p. 220, pl. 27, figs. 9–12.
1849. *N. primigenius*, R. W. Gibbes, Journ. Acad. Nat. Sci. Philad. ser. 2, vol. i. p. 195, pl. xxv. fig. 95.
1852. „ „ A. Quenstedt, "Handb. Petrefakt." p. 167, pl. 13, fig. 3.
1858. „ „ J. Probst, Württb. Jahreshefte, vol. xiv. pp. 124–127.
1877. „ „ R. Lawley, Atti Soc. Toscana Sci. Nat. pp. 66–68, pl. i. figs. 1–5.
1877. *N. recurvus*, R. Lawley, *ibid.* pp. 69, 70, pl. ii. fig. 1.
1879. „ „ J. Probst, Württb. Jahresh. vol. xxxv. pp. 162, 163, pl. iii. figs. 12–17.

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[1] In addition to *Notidanus dentatus*, the National Collection also comprises three teeth of *Oxyrhina* and one of *Odontaspis* from these beds; the former bear a very close resemblance to the common *O. Mantelli* of the European Cretaceous, though there are not sufficient materials to establish their identity; and the *Odontaspis* is indistinguishable from the well-known *O. subulata* of the same age.

1879. *N. primigenius*, J. Probst, *ibid.* pp. 158–162, pl. iii. figs. 1–5.
1885. ,, ,, F. Noetling, Abh. Geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, pp. 17–19, pl. i. figs. 4, 5.

Among the fossil Notidanidæ, the dentition of *N. primigenius* appears to be more completely known than that of any other. Lawley in Italy, and Probst in Würtemberg, have both contributed to its elucidation, and though Agassiz stated that during his elaborate researches he had only succeeded in determining lower teeth, there can be little doubt now that he also figured some belonging to the upper series. It seems probable that fig. 13 of plate 27 in the "Poissons Fossiles" really represents a tooth of the upper jaw; and if the originals of figs. 4–8 are correctly associated with the others (which is perhaps questionable), these likewise must be referred to a similar situation: it is almost certain, too, that the so-called *N. recurvus* is an upper tooth of the same species.

In the mandibular teeth of *N. primigenius* (Fig. 22), the principal cone is only slightly longer and more robust than that immediately following, but the lower part of its anterior edge is much produced forwards and bears a number of small serrations, which decrease in size from above downwards. The secondary cones gradually diminish as they approach the hinder end of the crown, and of these there are usually five or six. The median lower tooth is not yet certainly known, although both Probst and Lawley venture to claim its discovery. The former figures it as having a median cone, while the latter represents it as possessing only lateral cones—so that as it is impossible for these to belong to the same species, neither determination can be accepted as correct until more satisfactory evidence of association is forthcoming.[1]

(*To be continued in our next Number.*)

III.—Notes on Jurassic Brachiopoda.

By S. S. Buckman, F.G.S.

THE following notes relate to two Brachiopods—a *Rhynchonella* and a *Terebratula*—figured by the late Dr. Davidson in his last plates in the Palæontographical. Of the first a change of name is necessary; of the second, I consider that the identification needs revision, and that it deserves a separate name. Both species are from the Inferior Oolite.

Rhynchonella liostraca, S. Buck.

1883. *Rhynchonella bilobata*, S. Buck., Brachiopoda Inf. Ool. Dorset, Nat. Hist. Soc. Proc. vol. iv. p. 50.
1884. ———— *bilobata*, Davidson, Appendix to Supplement Brachiopoda, Palæontographical Soc. Proc. vol. 38, plate 19, figs. 18, 19.

Having given the above references, there can exist no doubt as to the species intended; but having subsequently found that the name *bilobata* had been used for a species of *Rhynchonella* previous to my applying it to this one, I take an early opportunity of altering the name of the species to *Rhynchonella liostraca.*

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[1] In his second paper (1879) Probst confirms his original determination (1858) and suggests that Lawley's fossil probably belongs to *N. gigas* or *N. Meneghinii*.

The late Dr. Davidson, whose kind assistance I have so often experienced, gave capital figures in his Brachiopoda (reference quoted above) of this most peculiar species. In the Inferior Oolite of England there is not as far as is known any species that at all approaches to this one in character, or with which it could possibly be confounded. The complete absence of any ribs, except just at the junction of the valves at the base, has induced me to give it the name of *liostraca*. It is an extremely rare form, and has only been met with at a few places. There are probably not more than eight or nine examples known. Its horizon is the *Sowerbyi* zone at one or two quarries near Bradford Abbas in Dorset, and near Corton Denham in Somerset.

The late Dr. Davidson, under the name *bilobata*, figured the types of this species, both of which were collected by myself. The one represented in fig. 18 I presented to Dr. Davidson, and it is now probably in the Natural History Museum.

The only species at all resembling this one with which I am acquainted is *Rhynch. trigona*, Quenstedt, Brachiopoda, plate 40, fig. 71; but, as I stated in first describing this species, it differs from *Rh. trigona* in having a well-marked deepish furrow in dorsal valve, no ribs at all, but only notched at base, and dorsal valve convex from beak to base.

TEREBRATULA EUIDES, S. Buck.

1883. *Terebratula dorsoplana* Buck., non Waagen. Proc. Dorset Nat. Hist. Soc. vol. iv. page 14.
1884. *Terebratula Fleischeri*? Davidson, non Oppel. Brachiopoda, Palæont. Soc. Proc. Appendix to Supplement, plate 19, figs. 4–4*a*, page 262.

This peculiar biplicated species has been a considerable puzzle. As can be seen, I referred it to *Terebratula dorsoplana*, Waagen;[1] but Dr. Davidson, in the course of correspondence with Dr. Waagen on the subject, came to the conclusion that this identification was incorrect, a view in which I now also concur. In fact, a comparison of the beaks of the specimens as represented by Waagen and Davidson will show the difference. The foramen in Waagen's figure being very small, separated from the umbo, and showing the deltidium, while this species possesses a large circular foramen almost touching the umbo. One point that is not quite brought out in Davidson's figure is the rather pinched appearance of the beak, in consequence of rather prominent beak ridges and a carina down the middle of the ventral valve.

Dr. Davidson referred this species to *Terebratula Fleischeri*, Oppel, but with this I cannot agree. Dr. Oppel[2] took as the type of his *Tereb. Fleischeri* the specimen figured by Davidson, Jurassic Brachiopoda, Pal. Soc. pl. xiii. fig. 7, which is an elongated slightly biplicated shell, much longer and narrower than the one under discussion, and it lacks the peculiar beak ridges and pinched appearance of the beak.

[1] Geog. Pal. Beiträge, plate 31(8), fig. 7.

[2] Oppel, Juraformation, page 497.

Our species has often been confounded with *Tereb. perovalis*, Sow., and *Tereb. Stephani*, Davidson. From the first it is easily distinguishable by its larger plications and its carina down the larger valve, but these characteristics unite it with *Tereb. Stephani*, from which, however, it may be distinguished by a shorter, less incurved beak, and its plications not extending so far up the valves. The characteristic beak ridges as mentioned before are not possessed by either of these other two species.

Terebratula euides is rather rare. It has been found chiefly in a quarry about two miles from Sherborne, in Dorset, in a sandy bed at the very bottom of the Murchisoniæ zone, along with *Terebratula simplex*, Buck., also at one or two other places near Sherborne. It is somewhat variable in width, and the edges of the valves are generally slightly thickened by lines of growth. I take as the type of this species Davidson's figure, Brachiopoda, Pal. Soc., Appendix to Supplement, plate 19, figs. 4, *4a*, which are drawn from a specimen in my collection.

This species is frequently longer and narrower than the specimen figured by Davidson, sometimes, but rarely, wider. The folds are also slightly variable.

IV.—The Igneous Rocks of Stanner.

By Grenville A. J. Cole, F.G.S.,

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THE area near Old Radnor marked by invitingly igneous colouring on Sheet 56 S.E. of the Geological Survey Map deserves attention from more than a petrographic point of view. Murchison, in his "Silurian System," has extolled the charms of the surrounding scenery, and the Rev. W. S. Symonds has repeated this admonition to the tourist. The borderland is in truth here eminently picturesque, from the great escarpment of the Ludlows to the high moor of Radnor Forest, the very stratified deposits yielding singular variety of form. The present paper, however, deals merely with one ridge, called Stanner Rock, comparison being occasionally made with its rival, Hanter Hill, from which it is divided only by a narrow vale.

Murchison[1] in 1839 compared the masses composing both these hills to the "hypersthene" rocks of Loch Coruisk, and stated that a variety of greenstones and "felspar rock" were also to be found. The differences, indeed, between specimens obtainable within short distances of one another may account for the fact that on the Survey Map Hanter Hill is coloured as syenite and Stanner Rock as greenstone; whereas Murchison clearly recognized the close relations of the main masses of the two. Dr. Callaway has also touched on the constitution of these hills when dealing with the Pre-Cambrian rocks of Shropshire,[2] and mentions a compact grey felstone as occurring in the centre of the ridge of Stanner Rock.

It is, indeed, at once apparent when one faces the bold cliff which terminates Stanner Rock that the dark mass is traversed by pale intrusive veins of a very different nature; and an examination of the "greenstone" itself reveals a number of dykes and veins of every variety of grain, reminding one of those cutting through the gabbros in the mountains round Coruisk. No true lavas or scoriaceous products remain about the flanks of Stanner, as about Corndon in the north or the Carneddau farther west; we have to deal largely with crystalline materials, which divide themselves at the outset into a more acid and a more basic series. The former, clearly intrusive in the latter, marks the later stages of eruption.

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[1] Silurian System, p. 318.

[2] Quart. Journ. Geol. Soc. vol. xxxv. p. 660.

With the relations of these masses to the surrounding deposits I am not as yet prepared to deal. Murchison's prediction that igneous intrusions underlie the altered Woolhope of Nash Scar[1] has not, so far as I am aware, been verified, and evidence of the penetration of this crystalline limestone by igneous veins is wanting at Brook Quarry and Yat Hill. I have failed to find satisfactory junctions between Stanner and Hanter Hill; but may add that I have not found pebbles from these hills in the ancient conglomerate of Old Radnor, which underlies the Woolhope Limestone. It is yet uncertain whether the local alteration can be attributed to faulting and to crushing down against hard earlier igneous masses, or whether it is due, as Murchison held, to the intrusion of those masses in times later than Silurian.

I. THE ACID SERIES.

The most highly crystalline member of this series is a pale pink-grey pegmatite—the word being employed in its original sense[2]—which passes from a well-developed graphic granite through finer varieties to a practically micropegmatitic form. This gradation is beautifully seen on the edge of a vein in Stanner cliff, of which a microscopic section has been prepared; where the cooling has been fairly rapid, along the line of junction with the more basic rock, a selvage of minuter graphic structure occurs, graduating off in a distance of 3 millimetres into the normal coarser form (Fig. 1).

This graphic granite is best developed in veins, not many inches wide, on the southernmost summit of Stanner Rock. Under polarized light the felspar presents the microcline structure, and extinguishes—as one would have inferred from its cleavage-surfaces on the rock-mass—uniformly over considerable areas. The areas of entangled quartz show similar optical connexion, as is the case in so many pegmatites, as though we dealt, not with isolated inclusions in a felspar, but with a complex intergrowth of large quartz and felspar crystals. Some portions exhibit a lamellar arrangement of the two constituents; but this appears to have no relation to proximity to the edges of the vein.

The rock is much cracked and faulted, minute bands of fault-rock appearing in microscopic sections. Hornblende prisms, and perhaps tourmaline, occur in a subordinate manner.

The less crystalline members of the Acid series are found in several dykes crossing the ridge approximately from east to west. In the hollow north of the pegmatite summit there is a considerable development of grey-white and compact felsite, which, from its frequent appearance at the surface, must form a great part of the centre of the hill. In section this rock is seen to contain scattered porphyritic crystals of quartz, a few plagioclase felspars, and irregular patches of fibrous hornblende, which is to all appearance secondary. Numerous small green prisms, often chloritized, are associated with the matrix, which consists of closely-set spherulites, often formed about minute felspars, the structure being only revealed by polarized light.[1] The radial lines of the spherulites are

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[1] See "Siluria," 5th edition, p. 108.

[2] Haüy, Traité de Min. 2nde édit. tome iv. p. 536. "De πηγμα, c'est-à-dire renfermant des pièces qui sont comme fichées dans une matière principale."

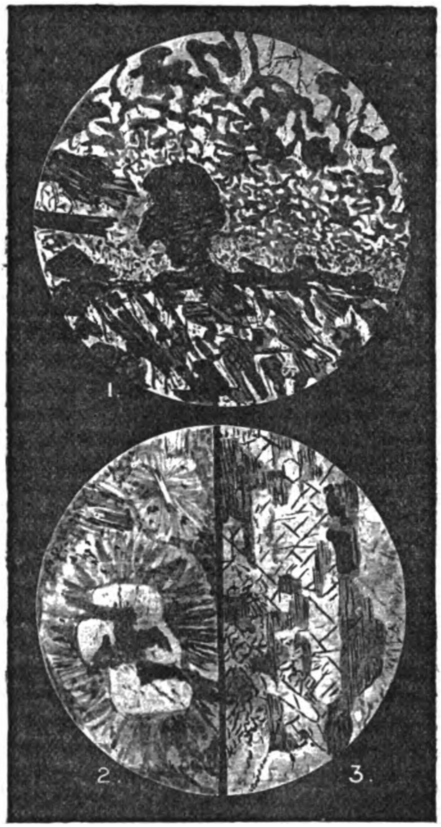

Fig. 1.—Section showing Junction of Pegmatite and "Diabase," Stanner Rock. × 7.
Fig. 2.—Section of Quartz-Felsite, Stanner Rock, showing corroded quartz and felspar microlite, serving as centres to spherulites. × 70.
Fig. 3.—Section of Augite-Diorite ("Diabase"), Stanner Rock, showing intergrowth of biotite and augite. × 70.

[1] Very similar rocks from eastern Victoria have been described by Mr. Howitt under Rosenbusch's name of Quartz-granophyrite ("The Rocks of Noyang," Trans. Roy. Soc. Victoria, 1883).

brought out distinctly, but, in place of the formation of a black cross, extinction occurs in two, three, or more sectors at a time, which yield coloured polarization in intermediate positions. This points to secondary crystallization having set in, with the usual passage from a glassy or cryptocrystalline to a microgranular condition. Just as the most detailed structures of the original glass, down to the forms of the minute included crystallites, are preserved in the secondary granules of our ancient rhyolites, so here the spherulitic form and structure remain, in spite of more complete crystallization of the mass. Under higher powers the polarization-effects of the sectors are themselves seen to be complex. A delicate feathery structure has developed, sometimes in pinnate diverging lines, sometimes as a mere network, and the areas into which the spherulite has divided have often become thus minutely pegmatitic. The network commonly extinguishes in one position, while the interspaces extinguish in another—a point best observed when magnified some 400 diameters.

MM. Fouqué and Lévy have figured[1] a quartz-porphyry from near Saulieu, Côte-d'Or, which is almost the precise counterpart of the felsitic rocks of Stanner. They find in the spherulites surrounding porphyritic and corroded crystals of quartz a network that extinguishes simultaneously with the pre-existing central crystal; a complete predominance of this material in the spherulite gives rise to what they have termed *Quartz globulaire*. The micropegmatitic structure of these authors appears to give similar effects, as if the radiating lines of quartz were an attempt to enlarge in optical continuity the crystal about which they have developed.[2] A dyke running E.N.E. in the wood upon the northern slope of Stanner contains, in addition to a multitude of orthoclase and plagioclase microlites, numerous corroded grains of quartz; each of the latter has served as a centre of devitrification (Fig. 2), and in several instances the highly-interesting observation of MM. Fouqué and Lévy may be repeated on these British spherulites. When comparison is made with similar rocks of much more recent date, it appears at least probable that the mesh-work structure (of quartz and felspar?) is in reality of secondary origin. So far as I am aware, it does not occur, at any rate freely, among the compactly-spherulitic rhyolites of later Tertiary days; but in a dyke traversing the Lias of Broadford, Isle of Skye, and belonging to the pre-Miocene series of eruptions, we have what looks remarkably like the commencement of such a structure by alteration. The spherulites mostly exhibit a dark cross, with, however, a tendency towards a granular condition; and the meshy micropegmatitic appearance occurs only in a few individuals, in a manner strongly suggesting a development of quartz among their previously homogeneous fibres.[3] It is quite conceivable that such secondary quartz might adopt the orientation of an included and rounded crystal, just as it is known to do when deposited in sandstones from solution.

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[1] Minéralogie micrographique, pl. xii. fig. i.

[2] *Ibid*, pp. 193–94.

[3] Cf. Judd, Quart. Journ. Geol. Soc. vol. xlii. p. 72.

In order to see whether the felsites of Stanner could be correlated with the clearly acid and more crystalline pegmatite, as common offshoots of some granite mass below, I made the following analysis of a specimen from the central area. The specific gravity, determined from a large specimen by Attwood's balance, is 2·62.

SPHERULITIC QUARTZ-FELSITE, STANNER ROCK.

SiO_2	74·80
Al_2O_3... ...	13·89
Fe_2O_3... ...	trace
CaO	2·59
MgO	·05
K_2O	2·74
Na_2O... ...	5·45
Loss on Ignition	·77
	100·29

The rock belongs, then, fairly to the Acid series, but to the "granitite" rather than the granite group; similar proportions of the alkalies, implying a fair amount of oligoclase-material, are found even among the rhyolites.

I have not been fortunate enough to find these white felspathic rocks repeated on Hanter Hill, though the community of other characters in the two hills leads one to suspect that they occur.

II. THE "DIABASE" SERIES.

The greenstones that compose the bulk of Stanner Rock form various links in the series between the augite-plagioclase rocks and the ordinary hornblende-diorite group. In coarse-grained specimens from Hanter Hill, as well as from Stanner, green fibrous crystalline areas occur that by their extinctions may well be altered enstatite. The pale green products that abound, however, are very largely chloritic, and may be considered "tertiary" in origin, when, as is so frequently the case, they are derived from the acicular or the more massive hornblende that is itself developed at the expense of diallage or augite. Olivine was very probably a constituent part of the summit masses of Hanter Hill; and, following the nomenclature adopted by Prof. Judd,[1] the rock is there a diallage-gabbro traversed by veins of dolerite, to which the small rounded augites give a marked granulitic structure. The felspars are extensively "schillerized,"[2] and even the minuter augites of the dolerites are in the diallage condition, chloritic pseudomorphs resulting from their complete and final alteration. In one gabbro the passage from diallage into hornblende is very beautifully seen.

But many of the greenstones of Stanner show no signs of former olivine, while chlorite is extensively developed in them from diallage, augite, and green hornblende. In one fine-grained holocrystalline rock, with a specific gravity of 2·86, biotite and augite are closely intergrown (Fig. 3), and form, with plagioclase felspar, the chief original constituents. Titanoferrite and prisms of apatite are also present. The biotite and the augite alike pass into green products, among which hornblende is occasionally recognizable; and quartz often fills the interspaces between the sharply-defined ends of felspar prisms. In other specimens, notably in a coarse variety on the most northern summit, ophitic structure prevails, the felspar being labradorite, according to a determination by Szabó's method made by Mr. J. F. Brooks. The most finely-grained rock of this series appears as a compact grey-green vein above Stanner cliff, and, with its porphyritic plagioclase felspars characteristically corroded by the matrix, and its brown clouded patches of augite, at first difficult of recognition, must be classed as an augite-andesite, and, when fresh, must have resembled many Tertiary lava-flows. The whole of the foregoing altered series, from the decomposed (olivine) gabbros to this hemicrystalline vein, come, then, conveniently under the head of "Diabase." It is, however, this very comprehensiveness, sanctioned by long usage—witness "Diabasmandelstein"—that makes the name valueless when limited to one rock-species.

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[1] "Tertiary Gabbros, etc., of Scotland," Q. Journ. Geol. Soc. vol. xlii. p. 62.

[2] Judd, Q. J. G. S. vol. xli. p. 383.

Prof. Judd[1] has recently pronounced against "Diabase" in favour of "Gabbro" for coarsely-crystalline rocks that can be shown to have contained olivine as well as plagioclase and augite, and has discussed the current terminology from a basic point of view. Since there is a growing tendency to employ "Diabase" for the granitic augite-plagioclase rocks, thereby defining closely what has become a really valuable field-term, I may perhaps venture to give briefly a historic outline of the position.

In 1813 Alexandre Brongniart[2] put forward the name *Diabase* for rocks "composée essentiellement d'amphibole hornblende et de felspath compacte," including in this the famous orbicular rock of Corsica. Haüy[3] subsequently employed *Diorite* (implying the distinctness of the two constituents) for the same rocks, which he distinguished from syenite by a greater predominance of hornblende; and this name prevailed so far that Brongniart in 1827[4] very gracefully yielded up his prior term—invented, as he pathetically remarks, by one familiar with ancient and modern languages—lest science should be cumbered with two names for precisely the same thing. He admits diallage and mica among the accessory minerals of the *Diorite* which he thus helped to establish.

Diabase therefore ceased to exist, until Hausmann[5] very effectually revived it for the series of rocks containing "hypersthene," labradorite, *and chlorite*, varying in structure from highly-crystalline to scoriaceous, which he found associated with his two classes of Diallage-Labradorite and "Hypersthene"-Labradorite rocks. But this "hypersthene" being for the most part only a lustrous augite, analyses revealing its chemical identity with diallage,[6] Diabase naturally came to cover all augite-labradorite-chlorite rocks, of whatever grain, *i.e.* (pre-tertiary) altered masses verging on one side into the diorite, and on the other into the (olivine) gabbro series.

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[1] Quart. Journ. Geol. Soc. vol. xlii. pp. 61-2.

[2] "Essai d'une classification des roches," Journ. des Mines, July, 1813.

[3] Traité de Min. 2nde édit. tome iv. p. 536.

[4] Classification des roches homogènes et hétérogènes, p. 80.

[5] Ueber die Bildung des Harzgebirges, 1842.

[6] See vom Rath, "Chemische Untersuchungen einiger Grünsteine aus Schlesien," Poggend. Annalen, xcv. (1855) p. 545.

What, then, are we to do with the highly-crystalline representatives of the augite-andesites? It seems unnecessary to extend *Eucrité* (augite-anorthite rock), if we can employ some more familiar term. The bulk of the gabbros are, as Prof. Judd has shown, so connected with the basalts, that we are still left with a gap, and into this diabase has somewhat naturally stepped. Messrs. Hague and Iddings[1] employ it in this sense, connecting, in their admirable series of observations, diorite and hornblende-andesite, diabase and augite-andesite; and De Lapparent[2] also makes of his diabases a series exactly parallel to his (hornblende) diorites. But the difficulty of thus defining their position as distinct from diorite is shown by Bořický's[3] use of diabase for hornblende-plagioclase rocks where the former mineral can be shown to have been derived from augite; and the fact that many diorites are in this sense altered diabases must lead to considerable confusion,[4] two parts of the same mass retaining the same essential structure, and yet receiving different names.

Now Zirkel[5] has long ago given us a class of *augite-diorites* distinguished from his diabase by containing oligoclase and not labradorite; but now that the nature of the felspar no longer restricts the diorites, this class becomes correspondingly extended and fills admirably the vacant place. Augite and enstatite diorites should seem no more strange than the corresponding varieties of andesite, and the close relations of the pyroxenes and the amphiboles appear to support this comprehensive view, viz. that the diorites form a natural group, containing now hornblende, now mica, now augite, or now, as in the case of rocks at Stanner, two or even three of these constituents.

Diabase then remains much where Hausmann placed it, as a common term for the more basic altered augitic rocks, without question as to their age or much regard for structure. Not that it is better in itself than "Greenstone," but that it is sanctioned by more international usage. My excuse for dwelling thus far on what may seem foreign to the mere description of the rocks of Stanner lies in the fact that so many areas of augite-plagioclase rocks (Augite-Diorites) occur upon our western border. Vague and general terms are too valuable to be lost sight of in the field; but the use of an inexact name where another more closely expresses an observed relationship can only be, and has been in the past, a source of misapprehension and confusion.

Many of the rock-sections above referred to have been made, and the chemical work has been carried out, in the Geological Laboratory of the Normal School of Science and Royal School of Mines.

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[1] Bulletin U. S. Geol. Survey, No. 17.

[2] Traité de Géol. 2me édit. p. 627.

[3] Tscherm. Mittheil. ii. (1880) p. 78.

[4] See Hague and Iddings, Bull. U. S. Geol. Surv. No. 17, p. 21.

[5] Lehrbuch der Petrogr. (1866) ii. p. 7.

NOTICES OF MEMOIRS.

I.—REPORT ON A SERIES OF SPECIMENS OF THE DEPOSITS OF THE NILE DELTA, OBTAINED BY THE RECENT BORING OPERATIONS.

By J. W. JUDD, F.R.S., Pres. Geol. Soc. Proceedings of the Royal Society, No. 240, 1886, pp. 213–27.

THIS paper contains the results of a microscopic analysis of specimens from the borings, which have lately been carried on, under the auspices of the Royal Society, in three different places in the Nile Delta. That at Kasr-el-Nil, Cairo, was carried to a depth of 45 feet, whilst those at Kafr-ez-Zayat and Tantah, places about half-way between Cairo and the Mediterranean, were 73 and 84 feet deep respectively. In none of these borings was the rocky floor of the Nile valley reached. The beds passed through consisted of an admixture, in varying proportions, of blown sand and alluvial mud. The *sands*, when examined under the microscope, are seen to consist of two kinds of grains; the larger, usually perfectly rounded and polished, are of quartzitic materials evidently derived from granitic rocks, with particles of red and brown jasper, Lydian stone, fragments of silicified wood, nearly unaltered felspar grains, hornblende and jade. The smaller sand grains, often subangular and angular, include a greater variety of minerals than the larger, and comprise, in addition to those above mentioned, mica, augite, enstatite (?), tourmaline, sphene, iolite (cordierite), zircon, fluorspar, and magnetite, all in a nearly unaltered condition. These sand grains have been derived either directly from the breaking up of granitic and metamorphic rocks, or from older sandstones formed of the *débris* of these rocks.

The *mud* is singularly deficient in kaolin, and seems to be composed of extremely minute chips and flakes of quartz, felspar, mica, hornblende and other minerals, mingled with some organic particles and frustules of Diatomaceæ. In the Tantah boring fragments of tufaceous limestone were also met with.

The striking feature in the character of these delta deposits is the comparatively unaltered condition of the felspars and other complex silicates in the sands and muds, and the absence of kaolin. Under the usual processes of disintegration of rocks in temperate climates, the felspars and other silicates are reduced by chemical action to soluble silicates of potash, soda, etc., and carried away in solution, whilst the kaolin remains behind. It appears, however, from the nature of these deposits, and from the small amount of soluble solid matter in the water of the Nile, notwithstanding the concentration resulting from extensive evaporation, that chemical action has had but little effect in the drainage area of the Nile, in comparison with the mechanical influences resulting from extreme variations of temperature, the action of the winds, and torrential rains. G. J. H.

II.—UEBER DIE FOSSILEN SÄUGETHIER-UEBERRESTE VON BALTAVÁR. Von J. PETHÖ. Jahresbericht d. K. Ung. Geolog. Anstalt für 1884, pp. 63–73. Budapest, 1885.

ON THE FOSSIL MAMMALIAN REMAINS FRON BALTAVÁR. By Dr. J. PETHÖ. Annual Report of the Royal Hungarian Geological Survey for 1884.

ABOUT 35 years since, some remains of fossil mammalia were discovered near Baltavár, in the Trans-Danubian province of Hungary, which Prof. Suess determined to be nearly entirely identical with the Pikermi fauna. They consisted of the following species: *Machairodus cultridens*, *Hyæna hipparionum* (=*H. eximia*, Gaudry), *Dinotherium*, *Rhinoceros*, *Sus erymanthius*, *Antilope brevicornis*, *Helladotherium Duvernoyi*, and *Hippotherium gracile*. The deposit was supposed to have been exhausted, but now lately fresh remains have been discovered by the Hungarian Survey, and from these, and from the collection stored in an adjoining monastery, Dr. Pethö has determined the under-mentioned list of fresh species, which further show a remarkable connection with those from Pikermi. They include *Mesopithecus Pentelici*, Wagn., *Dinotherium giganteum*, Kaup, *Mastodon Pentelici*, Gaudr. et Lartet, *Tragoceros amaltheus*, Roth-Wagn., *Cervus*, sp., cf. *Matheronis*, Gerv., *Chalicotherium Baltavárensis*, n.sp., and *Rhinoceros pachygnathus*, Wagn.

REVIEWS.

THE SURVEY OF WESTERN PALESTINE. MEMOIR ON THE PHYSICAL GEOLOGY AND GEOGRAPHY OF ARABIA PETRÆA, PALESTINE, AND ADJOINING DISTRICTS, WITH SPECIAL REFERENCE TO THE MODE OF FORMATION OF THE JORDAN-ARABAH DEPRESSION AND THE DEAD SEA. By EDWARD HULL, LL.D., F.R.S., 4to. pp. 145, with Maps and Sections. (Published for the Committee of the Palestine Exploration Fund, 1886.)

IT is now generally recognized that the social and political history of the inhabitants of any country has been largely influenced by its physical characteristics, and that consequently in order to elucidate the one, it is necessary to obtain a thorough knowledge of the other. The Committee of the Palestine Exploration Fund, in its efforts to obtain a complete knowledge of the ancient inhabitants of Palestine, took therefore a wise step in organizing an expedition to this country to study its physical structure. Prof. Hull was chosen as the leader of the expedition, and the present memoir gives the outcome of his observations.

The geological features of Palestine and the adjoining regions have for many years past been pretty well known through the works of several competent investigators, amongst whom may be mentioned Bauerman, Lartet, Milne, Fraas, Ritter, Russegger, and others, and considerable light has also been thrown on its geology by the explorations of Zittel in the Libyan Desert. A very excellent résumé of the existing knowledge of the subject has been given by

Mr. W. H. Hudleston, in a presidential address to the Geologists' Association in 1882, to which the same author added further notes in March, 1885.

It can hardly be expected that in the course of the short period of two months, in which the active work of the Expedition was carried out, Prof. Hull should have been able to add very materially from his own observations to the already existing knowledge of the subject. But though the contents of this memoir have been, to no small extent, derived from secondary sources of information, it is still a valuable contribution to the geology of Palestine, and the statements and opinions it contains will be, by many, more relied on than those of equally competent but supposed less orthodox investigators. As a rule, however, Prof. Hull's researches confirm those of previous investigators. By a strange irony of fate indeed, the author has proved that one of his own pet theories of the former outflow of the Jordan, through the Arabah valley into the Red Sea, is not tenable, and he now finds the water-parting in this valley to be some hundreds of feet above the level which the waters of the Dead Sea basin reached, even in their greatest extension.

As regards the ancient crystalline rocks of the Sinaitic region, the author accepts, though somewhat hesitatingly, the views of Fraas and others that they are of Archæan or Laurentian age. On this supposition, the volcanic series which penetrates through them may be, the author states, "of Lower Silurian age, but if we consider the older schists to be metamorphosed Cambro-Silurian beds, then the newer series may be of Upper Silurian or of Devonian age." It would be interesting to know the grounds, if there are any, for considering these crystalline schists to be of Cambro-Silurian age. The author says in a footnote, "As in the case of those portions of the British Isles where the Lower Silurian rocks have been metamorphosed previous to the deposition of the Upper Silurian beds to which they are unconformable." We fail to derive any assistance from this remarkably indefinite comparison, and should have preferred to have had a more particular reference.

There is a great gap between the Archæan crystalline and volcanic rocks of the Sinaitic peninsula and the succeeding formation of purple and red sandstones, of Carboniferous age, which overlie them unconformably. In the Wady Nasb this sandstone is covered by a band of limestone, in which Mr. Bauerman discovered fragmentary fossils of Carboniferous age. Some doubt was thrown upon the determination of these fossils, but this expedition obtained others which decisively prove the Lower Carboniferous age of the limestone, and the sandstones beneath are also regarded as of the same period. The band of Carboniferous limestone is, in its turn, overlaid by sandstones of similar characters to those beds below it, and these higher or Nubian sandstones pass upwards into limestones of Cretaceous age, and are themselves probably of Cenomanian age. In the absence of the Carboniferous limestone band—which appears to be not extensively developed—there are no means of determining whether the basal beds of the variegated sandstones are Carboniferous or whether they are wholly Cretaceous and belong to the Nubian series. At the Wady Nasb the Carboniferous sandstone is from 150 to 250 feet in thickness, and Prof. Hull assigned to it the not very distinctive name of "the Desert Sandstone," whilst for the Cretaceous sandstone, which has an extremely wide development both in Palestine, the Sinaitic Peninsula, Egypt, and the Libyan Desert, the name of the "Nubian" Sandstone is retained.

Another outcrop of the Carboniferous Limestone is believed to have been met with by the Expedition among the hills of Moab, east of the Ghor, but "for lack of time" the fossils in it were not collected, and Prof. Hull does not therefore feel confidence respecting its age.

No fresh details of importance were noted respecting the Cretaceo-Nummulitic series of rocks of which the greater part of Palestine and of the country east of the Jordan valley is composed. The series consists of the Nubian Sandstone below, followed by thick beds of limestones with bands of chert. The succession and the character of the rocks very much resembles that described by Zittel in the Libyan Desert, and there is also a similar absence of any clear line of demarcation between the limestones of Cretaceous and those of Eocene age. Fossils appear to be rare throughout the series—the Expedition does not seem to have discovered any in fact. It would be interesting to know whether the numerous bands and masses of flint and chert, which occur equally in the Cretaceous and in the Eocene strata, are, like those of the Upper Chalk of England, derived from siliceous sponges; but nothing is noted about them beyond that shells of Molluscs and Echinoderms now siliceous are occasionally found in them.

The author briefly refers to the occurrence of beds of a calcareous sandstone, the presence of which is stated to be the key to the physical features of the western margin of Palestine from Mount Carmel to beyond Gaza. No thickness is assigned to the deposit, its conformability or otherwise to the Eocene limestones below is not mentioned, and the only fossils in it are unrecognizable fragments of shells.

The author refers the formation provisionally to the Upper Eocene, "chiefly on the grounds: (1) that it is older than the sand and gravel of the 200 feet sea-border, which may be inferred to date back to the Pliocene: (2) that there is no evidence of any Miocene beds in Palestine; and (3) that the rock has a very solid character and is traversed by joint planes, similar to those of the Cretaceo-Nummulitic limestone." The rock may indeed belong to the Upper Eocene, but the grounds on which it is so placed are of the weakest character. Thus, because Miocene beds are not known elsewhere in Palestine, is certainly no argument why these beds may not belong to this period, and as for the very solid character of the rock being evidence of its Upper Eocene age, it is stated on the preceding page that this rock "*is sometimes rather solid, but generally porous.*"

With the great uncertainty respecting the age of this calcareous sandstone, it would seem to be rather premature on the part of the author to devote a chapter to the subject of "Miocene period unrepresented in Palestine and Border," in which it is stated that in

Palestine and Idumar this period is "one of disturbance and elevation, of faulting and flexuring and denudation of strata."

In the chapter on "Later Pliocene to Recent Beds (Pluvial)," the author points out that after the leading features of the land and coast-lines had been formed by denudation, there was a depression of about 220 feet in relation to the present sea-level. The evidence for this is the presence of raised beaches with recent shells in the vicinity of Cairo, also near Gaza and Jaffa at elevations of about 220 feet. The author also discovered recent corals and shells in gravelly beaches in the Arabah valley at elevations of 80 and 130 feet above the sea-level.

A depression of about 220 feet would unite the basins of the Red Sea with the Mediterranean, and at the shallowest part of the channel between them there would be a depth of 150 to 170 feet of water. On the theory of the union it is difficult to explain the remarkable differentiation which exists between the faunas of the Mediterranean and the Red Sea at the present day, for if there was such an open channel in Pliocene times, the period which has since elapsed does not seem sufficiently long to have given rise to the extreme dissimilarity which now exists. Prof. Hull assumes that the two seas were disconnected in Miocene times and that the differentiation which took place in that interval was not materially interfered with by the Pliocene communication; since the water was not deep enough to allow of free commingling of the two faunas. To most naturalists this will appear an unsatisfactory and untenable explanation.

The author refers in some detail to the terraces of marl silt and gravel with fresh-water shells in the more elevated beds, which mark the different elevations of the water in the Jordan-Arabah valley up to a level of about 1400 feet above the present surface of the Dead Sea, or about 100 feet above the Mediterranean.

The Jordan-Arabah depression is ascribed to the direct result of a fault or fissure of the crust, accompanied by a displacement of the strata, arising from the tangential pressure of the Earth's crust due to contraction, and the depression was produced at the close of the Eocene period. It is thought probable that the first waters of the Dead Sea basin were those remaining from the ocean itself, and that the fauna of the Lake of Tiberias may thus have had, in the main, a marine origin. The author does not venture to apply this theory to the distinctive species of *Unio* and other fresh-water mollusca, now inhabiting the Jordan Valley, but regards the fishes as the descendants of those which lived in the waters of the Eocene seas. It is, of course, possible, but we should like to have seen some facts brought forward in favour of the hypothesis.

According to the author this isolated basin-full of Eocene salt-water then suffered a process of contraction, whether from evaporation or otherwise, is not stated, and at the close of the Miocene, or at the commencement of the Pliocene, the waters had been reduced to about the level they are at present, and in the meantime the region was being carved out by denudation into the hills and valleys of the present day. This contraction is correlated with a similar reduction in volume of the Mediterranean Sea—whether both originate from a common cause is not stated; but whilst the reduction of the Mediterranean is inferred to have taken place "at an epoch not very remote and which may be represented by the Interglacial stage of the Quaternary period," the reduction of the Dead Sea is placed further back, at the beginning of the Pliocene.

The next stage in the geological history of the Dead Sea to which the author introduces us is that of "The Pluvial Period (Pliocene and Post-Pliocene)," in which there was a general subsidence of the whole region bordering the Levant and a general rising of the inland waters, till the Jordan-Arabah depression was filled by a lake (fresh-water?) over 200 miles in length and over 2000 feet in depth. This great change appears to have been produced by the climate of the Glacial period, when the temperature of Palestine is stated to have been 25° Fah. lower than at present, and the climate resembled that of the British Isles. But the Dead Sea basin even then was not filled to the brim, and it would at that time have required no small engineering capacity to have cut a canal through the water parting in the Arabah valley, to unite its waters with those of the Red Sea.

Subsequently to the Pluvial period we are told by the author that the more modern physical conditions set in, and by gradual degrees the waters in the Dead Sea basin were for a second time reduced to the low level now existing.

The author devotes a special chapter to the "Origin of the Saltness of the Dead Sea," from which it appears to be his opinion that it is merely owing to the concentration by evaporation of the saline ingredients which the rain-water of rivers and streams has dissolved out of the strata through which it passes.

The author makes the following novel comparison between the water of salt lakes and that of the ocean: "It is probable that the water of the ocean itself has become salt owing to the same cause which has produced saltness in the inland lakes, as it may be regarded as a mass of water without an outlet." It is, however, arguing in a circle to attribute the saltness of the ocean to the land, whilst the land itself, including the salt (leaving eruptive rocks out of the question), may be attributed to the ocean.

The author makes no allusion to what has become of the enormous mass of solid materials which has been removed from the surface of the drainage area of the Dead Sea, and carried into its basin. Some of it is, of course, represented by the terrace deposits, but we can hardly account for the rest, without supposing that the depression of the Dead Sea has originally been much deeper than it is now, and that it has been partially infilled.

In an appendix Mr. F. W. Rudler describes the microscopic structure of the specimens of crystalline rocks collected by Prof. Hull in Arabia Petræa.

The work is illustrated by two geological maps and by numerous sections and profiles which show very distinctly the stratigraphical relations both of Palestine itself and the Sinaitic peninsula.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—March 24, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Genus *Diphyphyllum*, Lonsdale." By James Thomson, Esq., F.G.S.

The author commenced by giving a definition of the genus *Diphyphyllum*, and then proceeded to discuss its relations with some allied forms, such as *Lithostrotion*, *Lithodendron*, and *Campophyllum*. *Diphyphyllum* was shown to be restricted in Scotland to the lower portion of the Carboniferous system, and not to have survived the great development of volcanic action in the upper part of the Carboniferous-Limestone series, whereas in Belgium and elsewhere the range of this genus was more extensive.

It was shown that in *Diphyphyllum* reproduction took place both by fissiparity and by calicular gemmation, examples of both forms being cited. It was also pointed out that the development of central vertical plates, showing a tendency to a passage into *Lithostrotion*, was due to the corals having lived in a sea periodically affected by the influx of sediment from the neighbouring shore.

After a history of the views held by different writers since Lonsdale, and especially by M'Coy, Milne Edwards and Haime, Hall, Billings and De Koninck, on corals referred to this generic type, the author gave a description of the species found in North Britain, ten in number, of which seven were new; and after pointing out their differences, showed that all exhibit a tendency to vary, and that, if a sufficient series were available, a passage might be traced not only between these different species, but between *Diphyphyllum* and the various allied genera.

2. "On additional Evidence of the Occurrence of Glacial Conditions in the Palæozoic Era, and on the Geological Age of the Beds containing Plants of Mesozoic Type in India and Australia." By Dr. W. T. Blanford, F.R.S., Sec. G.S.

After recapitulating briefly the principal facts known as to the correlation of the Karoo formation of South Africa, the Gondwána system of India, and the Coal-measures and associated beds of Eastern Australia, and especially noticing those phenomena in the different strata that had been attributed to the action of ice, the author proceeded to describe the additions recently made to previous knowledge by various members, past or present, of the Geological Survey of India, and especially by Mr. R. Oldham and Dr. Waagen. These additions had recently been published in the Records of the Geological Survey of India.

Mr. R. Oldham, in a recent visit to Australia, had come to the same conclusion as all other geologists who had visited the country, and clearly showed, as the Rev. W. B. Clarke and many others had done, that beds containing *Glossopteris*, *Phyllotheca*, and *Nœggerathiopsis* were intercalated among marine beds with Carboniferous fossils. The age of these marine beds was shown by Dr. Waagen to be that of the European Coal-measures. Mr. Oldham, had however, further ascertained the presence in abundance of smoothed and striated boulders, evidently transported by ice, in the marine Carboniferous beds north of Newcastle, N.S.W., and he consequently considered these beds, and not the overlying Hawkesbury, the equivalents of the Bacchus-marsh beds of Victoria, and of the Talchirs of India, a view which was in accordance with the relations of the fossil flora.

Meantime Dr. Waagen had received from Dr. H. Warth some fossils from the Salt-range of the Punjab. The fossils came from the upper part of a boulder-bed, the resemblance of which to the Talchir group at the base of the Gondwána system had long been recognized, but which had hitherto been classed with a stage immediately overlying, containing Upper Cretaceous fossils. The fossils now found by Dr. Warth included two forms of *Conularia* found in the Australian Carboniferous rocks, besides some other species evidently of Carboniferous age. Dr. Waagen consequently classed the boulder-bed together with other similar formations in other parts of the Salt-range as Carboniferous. There was one difficulty, the fossils just referred to were considered by Mr. Wynne to be contained in pebbles derivative from another bed. It was, however, shown that this did not affect the age of other boulder-beds in the Salt-range, and that the latter were connected with the Talchir beds in Central India by another discovery of Mr. R. Oldham's that a boulder-bed in the Indian deserts was also probably of Talchir age, and that the question as to whether the nodules containing the *Conulariæ*, etc., were concretions or pebbles, might await further examination in the field.

Another contribution to the question had been made by Mr. Griesbach, who had recently found a boulder-bed which, from its character and fossils, he considered as Talchir, in the neighbourhood of Herat.

It was pointed out that the existence, over such extensive areas, of boulder-beds, all of which might, without any improbability, be of approximately the same age, rendered it highly probable that all were really contemporaneous and due to one Glacial period; that this period must have been towards the close of the Palæozoic era, which it may possibly have terminated by exterminating many of the principal forms of life. The peculiar flora of the Australian Newcastle beds and of the Indian Damudas, having nothing in common with the contemporaneous European Carboniferous flora, afforded an important proof of distinct botanical provinces in past times.

II.—April 7, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On Glacial Shell-beds in British Columbia." By G. W. Lamplugh, Esq. Communicated by Clement Reid, Esq., F.G.S.

This paper was divided into two parts, relating respectively to Vancouver Island and the Fraser Valley. Having to spend nearly a month at the city of Victoria in 1884, the author had leisure for the investigation of the geological features of the district, but he expressed his regret that, at the time, he was unacquainted with the publications of Mr. Bauerman and Dr. Dawson on the subject.

The most important shell-beds were disclosed in an excavation for a dry dock at Esquimault, V.I. Here a fissure in an igneous rock had been filled in by glacial beds. Shells were most numerous on the north side of the dock in Boulder-clay, associated with irregular sandy seams, the whole being softer than the general mass. The containing rock was not glaciated at this point. *Leda*, *Nucula*, *Cardium*, *Tellina*, *Mya*, and *Saxicava* are the principal genera.

There was great difference in the state of preservation according to position; the shells below the water-line being remarkably fresh, while acidulous waters, engendered by vegetable decay, had attacked the upper portions.

The author concludes that the whole mass of drift, including the shells, had been pushed up by ice in its passage southwards. The general mode of occurrence was very similar to that at Bridlington. He further observed that the rocks were not striated in the first instance by these shelly clays, but he believed the glaciation to have taken place through the action of harder substances, and that afterwards a milder term set in, when an arctic fauna established itself in the neighbourhood, after which fresh ice pushed the sea-bottom along with other accumulations into its present position.

The shell-beds in the Fraser Valley are about 100 feet above sea-level. Three sections of glacial beds were given. The stratified clay in which the shells were found contains no pebbles, and, though somewhat disturbed, has evidently been deposited where it now occurs.

2. "On a Lower Jaw of *Machærodus* from the 'Forest-Bed,' Kessingland." By James Backhouse, Esq., F.G.S.

The author believed that hitherto no example of a lower jaw of *Machærodus* has been met with in this country; he consequently gave a detailed description and measurements of a right mandibular ramus obtained by him from the Forest-bed at Kessingland, in Suffolk. Owing to the imperfect condition of the incisors and canines, it was impossible to say whether these teeth were serrulated or not, and consequently it was uncertain whether the bone belonged to *Machærodus cultridens* or *M. latidens.*

3. "A Contribution to the History of the Cetacea of the Norfolk 'Forest-Bed.'" By E. Tulley Newton, Esq., F.G.S.

This paper was principally devoted to the description of two fossil specimens. The first of these was a tooth, shown by external and microscopical characters to have belonged in all probability to the Sperm-whale, *Physeter macrocephalus.* The specimen was obtained by Mr. Clement Reid, at Sidestrand. The second fossil, also from Sidestrand, and now in the possession of Mr. James Backhouse, consisted of the right half of the seven anchylosed cervical vertebræ of a species of *Balæna.* The specific determination was less certain in this case; but the form approached most nearly to that of *B. biscay-*

ensis. Of other vertebræ from the Forest-bed, one, a caudal, was referred to *Balæna;* another, from the lumbar region, to *Balænoptera.*

The following specimens were exhibited:—

A series of Plant-remains from the Cromer Forest-bed, exhibited by Clement Reid, Esq., F.G.S.

Specimens from the Shell-beds in British Columbia, exhibited by G. W. Lamplugh, Esq., in illustration of his paper.

Specimens from the "Forest-bed," exhibited by James Backhouse, Esq., and E. Tulley Newton, Esq., in illustration of their papers.

CORRESPONDENCE.

ON THE DISTRIBUTION OF *HIPPOPOTAMUS AMPHIBIUS.*

SIR,—I have lately read with great pleasure Dr. Henry Woodward's interesting and instructive article, on "Recent and Fossil Hippopotami," published in Dec. III. Vol. III. 1886, pp. 114–118, of this MAGAZINE. In that paper, Dr. Woodward assigns to the two species of Hippopotamuses the tropical or warmer parts of Africa as their present habitats. As a generalization of their present distribution, this statement may be accepted as strictly correct, but during my journeyings in South Africa, in the upland regions of Natal, the Orange Free State, and elsewhere, I was surprised to find some of the reedy "*vleys*" or lakes called "*Leekoe Vley.*" Such a name is in itself evidence that the Boer immigrants, or early settlers, found Hippopotamuses in such localities; indeed, I have been informed by old settlers that such had been the case in their own knowledge, or else that the natives had told them of the former existence of the animals in such places. I have been credibly informed that 50 years ago Hippopotamuses were abundant in the Umzinduzi river, close to where now the city of Pietermaritzburg in Natal is built. The fact of these animals having inhabited localities in the uplands of Natal, and the Free State, is I think beyond question, and as those districts are at times subjected to very inclement weather, it raises the question whether the *Hippopotamus amphibius* is not capable of enduring far greater changes of temperature than is usually supposed. I was encamped in the vicinity of Newcastle, Natal, on the borders of the Transvaal, in the winter of 1881 (*i.e.* the summer of our northern hemisphere), and we experienced very severe weather. Water froze in the buckets left outside the tents at night, the snow lay deep over the country, herds of sheep and cattle were buried and frozen to death in the snow. Many farmers suffered great loss in stock. In the highlands of the Orange Free State, across the Natal border, the losses of flocks and herds from the snowstorms were greater than in Natal. The question arises, whether Hippopotamuses were denizens of these upland lakes and rivers, or only summer visitors. If residents, they must have been subjected at times to extraordinary changes of climate. I regret that during my residence in South Africa, I did not pay more attention to this interesting subject.

I venture to send you this communication in the hope that it may attract the attention of some naturalist in South Africa, of greater experience than myself, as the subject is one of considerable interest to the geologist.—I am, Sir, your obedient servant,

Wells, Norfolk, *2nd April*, 1886. H. W. Feilden.

DISCOVERIES IN THE PUNJAB SALT-RANGE.

Sir,—Since the abstract of my paper to the Royal Geol. Soc. of Ireland on the subject of Dr. Warth's discoveries in the Eastern Salt-range appeared in the Geological Magazine for March, a paper on the same subject by Dr. Waagen, of Prague, in the Records of the Geol. Survey of India (vol. xix. pt. 1), has reached me. Several points in this paper relate to the stratigraphy of the Salt-range as interpreted in my Geological Survey Report, and one or two especially touch portions of my paper referred to, and its abstract.

With reference to these last, I may notice that certain of the fossils to which I alluded as undetermined have now been fully described by Dr. Waagen, and are referred to the Carboniferous, not Devonian age, as I had been informed. Beyond accepting the purely palæontological determinations of Dr. Waagen, I have little to say: he gives his evidence, describing most of the species as new or indeterminate, or requiring further comparison, and he appears to be *now* satisfied as to their age. Their reference to the later period tends to reduce the interest which the discovery of Devonian forms would have possessed, on account of the absence of recognizable Devonian rocks, in that or the adjacent country.

Dr. Waagen's paper, however, differs from my own in describing these fossils as having been found in concretions, not in pebbles, and as occurring *in situ* in the *Conularia* layer. Upon this point rest very extensive and important deductions, and it is one upon which some uncertainty seems to have prevailed, leading both Dr. Warth and Dr. Waagen to reconsider matters and to change their minds: hence I am glad to learn we may expect to hear further about the matter from the officers of the Geological Survey of India.

Dr. Waagen's latest announcements, as above stated, seem to date from the end of last year or the very commencement of 1886. Dr. Warth, writing to me with specimens from this layer (and some others) under date Dec. 1, 1885, strongly maintains that the fossils are not *in situ*, but derived, and in support of this he calls attention to one of the specimens, a single rolled fossil *Conularia*, which itself formed one of the pebbles of the layer. Turning to the specimens I received (and they were few), I found they consisted of fine, pale, non-calcareous sandstone, presenting no signs of concretionary structure, their smoothed surfaces intersecting the inclosed fossils, while the special example referred to has all the appearance of a once more perfect fossil detached from its matrix, abraded and rolled till its general form alone remains, with just sufficient of its original markings to show certainly what it is. Another of the same kind shows only the outer form, and greater abrasion.

On this confirmatory evidence I adhere to the view expressed in my paper as to the derived or *remanié* character of the *Conularia* layer, until something more conclusive is brought forward than has been yet produced.

The "Olive group" of the Salt-range which contains this *Conularia* layer, from its circumstances of position and from a few of its fossils, found in a determinable state, was classified by Dr. Waagen and myself as probably of Cretaceous age, before he left the Punjab.

It has been recorded for years that certain Boulder-beds, lying just beneath this *Conularia* layer, and included in the Olive group, contain glaciated blocks, and resemble the Talchír Boulder-beds of the Gondwána series in Peninsular India; also that there are in other parts of the Range, and at different vertical positions in its sections, Boulder-beds of very similar aspect.

I have never found reason to believe that the stratigraphic relations of these Salt-range Boulder-beds supports the idea now advanced, that all occur upon one and the same horizon; and I must say I am still unconvinced of the fact, while admitting that this would be both important and interesting if proved.

KINGSTOWN, 19*th March*, 1886. A. B. WYNNE.

THE PALÆONTOGRAPHICAL SOCIETY.

SIR,—The fortieth volume of the Memoirs of the Palæontographical Society is now in progress; with the current year the series will have completed the number generally assigned to a period of probation. That it has well endured the trial of time none can deny. The unremunerated labours of many of the leading palæontologists of Britain have enriched their fellow-workers with a series of monographs, sometimes dealing with various genera or classes, sometimes presenting a synoptic view of certain portions of the fauna or flora of an important Geological period. To these workers and to all who have taken an active part in the direction of the Palæontographical Society, geologists, not of Great Britain only, are deeply indebted. Never, we may confidently assert, has so magnificent a series of admirably illustrated monographs been placed in the hands of students or at so low a price. For an annual subscription of one guinea, a bulky volume is received, containing usually about thirty plates and three hundred pages of letterpress. At the present time monographs are in preparation or in progress on Pleistocene Mammals and Old Red Sandstone Fishes, on Jurassic Ammonites and Gasteropods, on Cretaceous Starfishes, on Palæozoic Sponges and on the Flora, both of the Carboniferous and of the Eocene periods. There is evidently no failure either in material or in writers. Moreover, up to the present time the Society has successfully paid its way and has occasionally had a small balance to the good. Death however of late years has unfortunately removed many of the original subscribers, and new members come in more slowly than might have been expected. Accordingly the Secretary announced at the last meeting of the Council that very shortly, unless there was a substantial increase in the number of subscribers, the quantity of matter included in the annual volume must be reduced, and thus the issue of the monographs delayed. This announcement is not altogether creditable to the geologists of Great Britain. The number of persons interested in the study of this science has not diminished, nay, has become decidedly larger, since the foundation of the Palæontographical Society. Many more than those whose names are on the list of subscribers could well spare the annual guinea needed to secure the efficiency of the work, but it may be feared that there is among them some lack of public spirit. The rapid development of every branch of geology has perhaps contributed to this by rendering its students more of specialists than they formerly were; but even if the number of monographs in the series bearing on this or that man's hobby be small, he is bound, I think, on public grounds to see that this useful work does not languish for want of funds. In almost every career of life there are certain associations to which one feels bound to belong: may I then be forgiven for suggesting that every geologist not absolutely impecunious should consider the Palæontographical Society one of these. True, the number of back volumes is now formidable to those who desire a complete set, but these can be purchased on easier terms by subscribers, and the less wealthy student may console himself for a broken series by the thought that he is doing a good work in securing its continuance.

T. G. Bonney.

NOTES ON PHENACODUS.

Sir,—I must remark on your late article on *Phenacodus*[1] (Geological Magazine, No. 260), that having selected for publication my earliest conclusions regarding it, issued in 1881, my more mature views are not stated. In order to insure the dissemination of the latter rather than the former, through your journal, I give the following points.

A few months after the publication of the note from which you have principally copied, I published a systematic analysis of the Ungulata in the Proceedings of the American Philosophical Society (1882), in which it was shown that the carpal bones in *Phenacodus* are in linear and not alternating series, and that it therefore cannot be referred to the Perissodactyla. With the Hyracoidea and other forms having similar carpal and tarsal characters it was placed in an order Taxeopoda. This order I regarded and still regard as ancestral to all Ungulata, Amblypoda and Proboscidea included. It thus realized, so far, the prophecy which I made in 1874 (Journal Academy Philad.), that the ancestral type of higher Mammalia would prove to be pentadactyle and bunodont. The history of this question is set forth in my illustrated account of the Condylarthra published in the "American Naturalist" for 1884.

A further study of the extinct Taxeopoda has shown me that although furnished with hoof-like unequal phalanges, they are not very different from the Lemurs of the primitive type known as the Adapidæ. I now believe that the order Taxeopoda must include not only *Phenacodus* and allies (=Condylarthra), but also Hyracoidea, Lemuroidea, Simmopithecoidea, and Anthropoidea, although the last-named diverge a little in the characters of the carpus. Moreover, some of the Taxeopoda of the Puerco epoch show that the Unguiculate forms can readily have descended from them, for as the carpus and tarsus of this order are thoroughly Unguiculate, it only requires intermediate forms of ungues to connect them, and these have been found. These facts and conclusions are set forth in the "American Naturalist" for 1885, in a paper on the "Evolution of the Vertebrata Progressive and Retrogressive."

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[1] See February No. pp. 49–52, Pl. II.

It thus appears that Lemurine forms were the ancestors of all Placental Mammalia, as was already anticipated by Haeckel in his far-seeing "Schöpfungsgeschichte." E. D. Cope.

NOTE ON *ERISICHTHE.*

Sir,—A careful perusal of Mr. Davies' note on this subject in your number for March reveals the fact that he agrees with me in the association of the fin-spines in question with *Erisichthe*, and not with *Ptychodus*. He corrects me as to the authorship of the term *Xiphias Dixoni*, and agrees with me again that the weapon of that species also belongs to the fish I have called *Erisichthe*. But he wishes me to use the name *Protosphyræna*, Leidy, in the place of the one I have proposed. In this point I hope Mr. Davies will yet again agree with me.

Two species are catalogued[1] by Leidy under the name of *Protosphyræna, P. ferox* and *P. striata*. If now his *P. ferox* be a species of the genus I have named *Erisichthe*, Leidy's name should, in accordance with all usage, be retained for the *P. striata*, provided the two belong to different genera. When in London, in 1878, either Mr. Davies or Mr. E. T. Newton showed me a jaw containing teeth of the *P. striata*, which was plainly not an *Erisichthe*. For this statement I depend on memory alone. If I be correct, it is for this genus that the name *Protosphyræna* should be retained, if it be used at all.

In its present status, however, the name in question is *nomen nudum*, and under the rules not more entitled to recognition than new names in museum or sale catalogues. The rules of the American and British Associations are explicit on this point, and properly so. E. D. Cope.

NOTOCHELYS COSTATA, OWEN.

Sir,—In his description of this interesting fossil,[2] Sir Richard Owen stated that the "nature and age of the deposit from which it came was unknown to him." I am informed by Prof. Archibald Liversidge, by whom *Notochelys* was sent to Prof. Owen, that it was found associated with certain other fossils described[3] by myself from the Cretaceous beds of Landsborough Creek, a tributary of the Thomson River, such as *Ancyloceras Flindarsi*, M'Coy, *Aucella Hughendensis*, Eth., sp., a probable *Hamites* and large *Inocerami*. These would appear to indicate beds about the horizon of the Marathon or Hughenden series of the late Mr. R. Daintree.[1]

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[1] The name is not referred to in the text of his paper by Leidy, but only appears in a catalogue at the end of it.

[2] Quart. Journ. Geol. Soc. 1882, vol. xxxviii. p. 178.

[3] Journ. R. Soc. New South Wales for 1883 [1884], vol. xvii. p. 87.

R. Etheridge, Jun.

THE LANDSLIP IN THE WARREN NEAR FOLKESTONE.

Sir,—It is only right that a record should be kept of the very extensive landslip which occurred in the undercliff of the Warren near Folkestone on the 19th January last, not only because few know anything of the circumstance, but that it might be useful in case of future investigations.

The area affected by this slip is very considerable, extending from the Warren House, near the Martello Tower, eastwards to a spot locally called the Jetty, a distance of nearly a mile in length and by about a quarter or rather less in breadth. This undercliff is entirely composed of rubble and *débris* from the Chalk cliffs above, which have been falling and slipping over for centuries. This slip appears to have taken a horizontal line from the seaward side of the railway cutting, in fact, in some parts it started from the outside of the actual railway bank. Had it broken away a few yards further inland, and there is no reason why it should not have done so, the passengers by the South-Eastern would then realize the danger to which the line is exposed. This large area gave way and went down bodily for a depth of from 12 to 20 feet, varying in places; this had the effect of forcing up the beds upon the shore several feet in height for about a mile of the coast. Towards the east end of the slip, the Chalk-marl is raised nearly 20 feet. It is a remarkable coincidence that since this happened, there have not been any heavy seas upon this coast, consequently no further damage has been done; but when heavy seas do come in, which they inevitably must, they will wash away thousands of tons of the rotten rubble cliffs which, upon the shore-line, are composed for the most part of *débris* from the cuttings and tunnels, which when cleared away will give further impetus for another and perhaps a more disastrous landslip to take place.

The whole floor of the shore is much raised, with here and there a depression which is probably the level of the old shore. In one place the Upper Gault is raised into a hillock several feet high.

The coming spring will afford an excellent opportunity for those interested in Cretaceous geology to examine the Chalk-marl as it is now placed. I may add, the whole of this area is constantly moving, and another slip may occur at any moment.

F. G. Hilton Price.

13th April, 1886.

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[1] Quart. Journ. Geol. Soc. 1872, vol. xxviii. p. 279.

THE
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No. VI.—JUNE, 1886.

ORIGINAL ARTICLES.

I.—On Marekanite and its Allies.

By Professor John W. Judd, F.R.S.,
President of the Geological Society.

In almost every collection of minerals there may be found specimens of the curious little glassy balls, which, from the locality of their occurrence—the great Marekanka, near Okhotsk in Siberia—have received the name of *Marekanite.* These glassy balls are more or less perfectly rounded in form, they vary in their colour, through different shades of smoke-grey to orange-brown, while in size they range from the dimensions of a pea to those of a walnut. Most mineralogical treatises still continue to recognize Marekanite as a mineral, and class it either as a variety of Obsidian or of Pearlstone.

While totally disallowing the claim of Marekanite to rank as a mineral-species or even variety—the petrographer recognizes in this substance a type of rock, which proves to be by no means devoid of interest, when its properties are carefully studied, nor destitute of suggestiveness, when its mode of occurrence is thoughtfully considered.

Occurring as it does on a spot frequently visited by travellers, the appearance and surroundings of Marekanite have been very fully described; among others by Steller, Laxman, Allegretti and Pallas; it was the last-mentioned naturalist who appears to have made the rock widely known by sending specimens from St. Petersburgh to most of the Museums of Europe.

The first mineralogist who seems to have expressed an opinion on the *nature* of Marekanite was Sewergin, who in 1796 described it as a "Glasszeolite."[1] To this conclusion he was probably led by studying its behaviour with the blowpipe.

Lowitz and Gmelin made analyses of the substance,[2] and these, though very imperfect, as might be expected from the early date at which they were undertaken, showed the rock to contain a very high percentage of silica with some alumina and a small proportion of the alkalies and alkaline earths.

The author to whom we are however indebted for most of our knowledge of the properties of this curious substance is Klaproth, whose memoir entitled "Chemische Untersuchung des Marekanits"[1] was read before the Berlin Academy on the 15th May, 1812.

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[1] Nova Acta Acad. Petropol. T. xii. (1801) p. 237.

[2] Neue Nord Beitrag, vol. ii. p. 299.

Klaproth showed that the Marekanite-balls were sometimes almost colourless and translucent, at others dark-coloured and opaque; the former he found to have a specific gravity of 2·365, the latter of 2·335. The composition of the two varieties he determined to be as follows:—

	Transparent Variety.		Opaque Variety.
Silica	81·00	......	76·50
Alumina	9·50	......	10·50
Lime	0·43	......	0·50
Iron Oxide	0·60	......	1·00
Potash	2·70	......	2·70
Soda	4·50	......	4·50
Undetermined constituent	—	......	2·50
Water	0·50	......	0·50
	99·13		98·70

No more recent analyses of the rock would seem to have been published. Klaproth further showed that while many of these glass balls resist a tolerably smart blow with a hammer, yet when they do yield they break up into a mass of fine particles, like unannealed or toughened glass. He noticed, too, their singular behaviour when heated, which will be described in the sequel.

Klaproth's analyses show that Marekanite is an obsidian, and if his separation of the soda and potash can be relied upon, which is doubtful, we might conclude that it is a dacite- or quartz-andesite-glass rather than a rhyolite- or quartz-trachyte-glass.

With the exception of some observations by Erman[2] and Herter,[3] but little seems to have been added to our knowledge of Marekanite since the time of Klaproth.

Professor Bonney informs me that the late Professor W. H. Miller, of Cambridge, told him that Marekanite-balls had been known to explode spontaneously. Mr. J. Gregory some time ago communicated to me the interesting fact that a lapidary who had attempted to cut a section of a Marekanite-ball found that during the operation it flew to pieces with a slight explosion. Kalkowsky states that many of the Marekanite-nodules, when struck with a hammer, decrepitate to dust.[4]

In these characters the balls of Marekanite appear to present so many points of resemblance with the well-known "Rupert's drops" that I thought it would be of interest to make a fuller comparison of the natural and artificial substances.

In the first place, the more transparent varieties of Marekanite, when examined between crossed Nicols, were found to depolarize the light in a very striking manner, giving rise to the well-known appearance presented by unannealed glass or glass when subjected to mechanical strain. Compared with the appearances presented by transparent Rupert's drops between crossed Nicols, the Marekanite was found to be precisely similar in its behaviour.

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[1] Berlin Abhandl. Physikal Klasse (1812—13), pp. 49—58.
[2] Archiv. f. d. Wissensch. Kunde von Rusal. iii. (1843), p. 175.
[3] Zeitschr. d. d. Geolog. Ges. xv. (1863), p. 459.
[4] "Elemente der Lithologie" (1886), p. 80.

In the second place, ten nodules of Marekanite, varying in size and colour, were selected for cutting by the lapidaries' wheel; and their behaviour, carefully watched, was as follows:—

One, the largest, was cut through without undergoing fracture.

Six, while being cut, had one or more cracks developed in them, and the formation of these cracks was accompanied by distinctly audible, snapping sounds.

In the remaining *three* cases, snapping sounds were heard from time to time while the cutting was taking place, and when the mass was nearly cut through, a distinct explosion occurred, the fragments being thrown to the distance of several yards.

In the case of two Rupert's drops, treated in precisely the same manner, it was found that before the saw had passed half through them, an explosion occurred, which was more violent than that accompanying the breaking up of the Marekanite-nodules. These facts point to the conclusion that the glass of the Marekanite-balls is *in a condition of intense strain*, in some cases approaching that which characterizes the Rupert's drops.

In the case of both the Rupert's drops and the Marekanite-balls, the portion left embedded in the cement after the explosion was found to be traversed by a system of radial cracks, and on the attempt being made to grind them they fell to pieces. The fine splinters into which the Marekanite-balls broke up were found, when examined by the microscope, to be quite similar to those derived from the Rupert's drops. Acting upon a suggestion made to me by my colleague, Prof. F. Guthrie, F.R.S., I annealed some of the Marekanite-balls by heating and slowly cooling them. They were then found to have lost their power of depolarizing light, and were easily cut and ground into thin sections.

I must now proceed to describe another set of remarkable phenomena—those namely which are exhibited by the Marekanite-nodules when they are heated.

If one of the balls be subjected to a gas-jet, blown by a moderately strong air-current, it will be seen that, as redness is approached, thin films of glass detach themselves from the surface of the ball and these films are successively broken up into fine particles, so that there is maintained a constant dispersal of excessively minute glassy dust, which is thrown to a considerable distance. If the temperature be now raised to whiteness, the whole mass swells up in cauliflower-like excrescences, till it has attained eight or ten times its original bulk. The resulting white mass is found to be a true pumice, which floats upon water, and microscopic sections of it are indeed quite undistinguishable in appearance from many natural pumices. Some of the Marekanite-balls, however, exhibit this property in a much more striking manner than do others.

These experiments prove that the quantity of volatile ingredients in these Marekanite-balls is very great, sufficient indeed, on being liberated by heat, to convert the obsidian into a pumice. Herter states that Marekanite loses on ignition from one to four per cent. of its weight.

The last point to which I have to direct attention with respect to Marekanite is its microscopic structure. This is found to differ in a remarkable degree in the several varieties.

Some of the Marekanite-balls are almost colourless and perfectly translucent. These, as pointed out by Zirkel,[1] are among the purest of natural glasses, and are comparable to Fulgurite and Boutellenstein.[2] From these translucent varieties we found every gradation to the more opaque types which are of deep smoke-grey and orange-brown tints, their opacity being evidently due to primary devitrification.

Porphyritic crystals are rare, and of small size in Marekanite. Those observed appear to be referable to hornblende, magnetite, and a brown mica. Black trichites and reddish or yellowish-brown globulites abound, the latter being usually drawn out by the movement of the glass into cloud-like wisps, and the rock being very distinctly banded by the disposition of these in the mass.[3] In many cases the commencement of a pumiceous structure is exhibited through the abundance of cavities drawn out in the direction of the flow. The Marekanite-nodules exhibit all the characters of a volcanic glass undergoing incipient devitrification and exhibiting flow structure, with occasionally the beginnings of pumiceous distension.

Now the peculiar characters of Marekanite seem to be capable of simple explanation when we take into account its mode of occurrence, which has been so clearly described by Erman and other writers.[4]

According to the information supplied from these different sources, there occurs in the district around Okhotsk a considerable tract of highly acid, igneous rock (rhyolite or quartz-andesite), which is sometimes vesicular, at other times compact, and appears to be sometimes intrusive in strata containing Devonian plants. This rock is generally stony in texture, but sometimes passes into "hornstone-like" varieties; while locally, as on the banks of the great Marekanka brook, it assumes a more or less pefectly glassy condition. At the locality mentioned, the igneous mass forms a cliff between 200 and 300 feet in height, the rock varying in colour from snow-white to reddish-brown, and its different varieties constituting wavy bands, which, as is so commonly the case with the vitreous lavas, simulate the appearances presented by many crumpled, foliated rocks.[5] This banded, glassy rock is seen to be traversed by numerous concentric joints, so that globular masses breaking up like onions accumulate in immense numbers at the foot of the cliff, forming a talus which reaches half-way to its top. The nuclei of these concentric masses, which vary in size from a pea to a fist, constitute the well-known bodies usually called Marekanite.

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[1] Mikroskop. Beschaff. der Mineralien und Gesteine (1873), p. 351.

[2] *See* Wichmann, Zeitsch. d. d. Geol. Ges. xxxv. p. 849; Diller, Amer. Journ. Sc. xxviii. p. 252; Rutley, Quart. Journ. Geol. Soc. vol. xli. (1885), p. 152.

[3] Compare Zirkel, Mikroskop. Beschaff. der Mineralien und Gesteine (1873), p. 361.

[4] Erman, Archiv. f. d. Wissensch. Kunde Russlands, iii. (1843), p. 175; Herter, Zeitsch. d. d. Geol. Ges. xv. (1863), p. 459.

[5] See Geol. Mag. Dec. II. Vol. II. pp. 68 and 69, Fig. 9.

A number of rocks have been described from other localities, which in their peculiar characters or mode of occurrence appear to closely resemble Marekanite.

In 1844 Damour gave an account of a specimen of obsidian,[1] which was said to have been obtained from India, though its locality could not be more precisely determined. It was spheroidal in form, and about 2⅓ inches in diameter; its colour was black by reflected light and bottle-green by transmitted light, and it had a specific gravity of 2·47. Unlike Marekanite, it was found to melt slowly without expansion, and to form a colourless glass. This ball of obsidian, while being cut by a lapidary, was found, when sawn through to the extent of nearly two-thirds of its diameter, to emit a kind of hissing sound, and this was followed by a strong detonation, the mass being at the same time broken up into fragments, which were thrown in all directions with considerable violence. The fragments when collected were found to show a radiated structure like that seen in the Marcasite-nodules of the Chalk.

The obsidian described by Damour was found by him to have the following composition, so that it must be regarded as a dacite-glass.

Silica	70·34
Alumina	8·63
Ferrous oxide	10·52
Manganous oxide	0·32
Lime	4·56
Magnesia	1·67
Soda	3·34
	99·38

It is said not to have lost weight on ignition.

In 1824 the late Mr. Poulett Scrope described[2] an interesting vein of green, porphyritic pitchstone with contorted banding, which occurs at the Chiaja di Luna in the Island of Ponza; he showed that the rock is made up of columns, each of which incloses a number of globiform masses that break up concentrically like gigantic onions. Mr. Scrope's drawing of this remarkable rock-mass is reproduced in the accompanying woodcut (see page 246).

In 1874 I had an opportunity of visiting this very interesting spot, and noticed a remarkable property exhibited by this green rock; when struck with a hammer, it broke up with curved planes of fracture parallel to the central nuclei; when freshly broken, the surfaces showed a perfectly vitreous lustre, but within a few seconds a most remarkable change was seen to take place over the glassy surfaces thus exposed. They appeared as though breathed upon and were gradually overspread by a whitish film, that looked like the bloom upon a peach; this white film was found to be permanent, and in consequence of its presence, specimens of the rock exhibit not the vitreous lustre of obsidian, but the duller lustre of pitchstone.[1]

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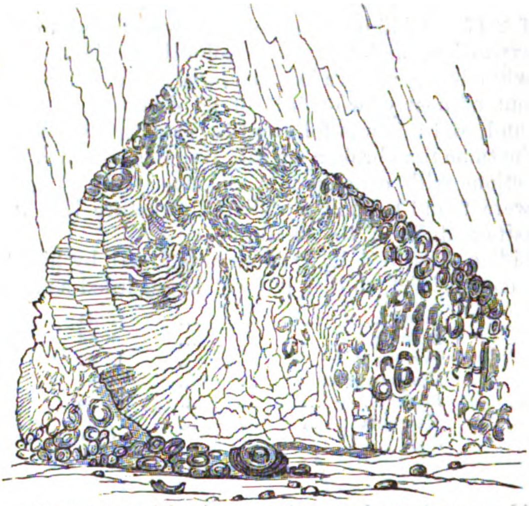
[1] Comptes rendus, vol. xviii. (1844), p. 46.

[2] Trans. Geol. Soc. 2nd ser. vol. ii. p. 205, plate 24. See also Volcanoes, 2nd ed. p. 105.

At the time when I made this observation, I thought that the remarkable change in the surface of the rock might be due to chemical action, and was the result of some kind of exudation on the freshly-formed surfaces. But subsequent study of the surfaces with the microscope, and discussion of the case with others, including Prof. Bonney and also Dr. Guthrie, who has paid much attention to the subject of the fracture of colloids,[2] has convinced me that the change is really *mechanical,* and one of a very peculiar kind.



Pitchstone Vein at Chiaja di Luna, Island of Ponza.

Experimenting with colloid substances, like plate-glass and Canada-balsam, I found that when relief from intense strain took place by the breaking of a mass which had been bent, till it could no longer resist the force applied, the fractured surfaces show a dull appearance, which under the microscope is seen to be caused by the wrinkling up of a thin film on the suddenly liberated surfaces. These cases differ from the one described from the Ponza Islands, in the circumstance of the appearance of the wrinkled film apparently *instantaneously,* instead of after an appreciable interval of time. But it is, I think, consistent with well-recognized physical principles that the recovery of particles from a condition of strain, which has been long maintained, should take place more slowly than that which follows from a strain of short duration.

The study of cases which we have been considering all point to the conclusion that, besides the local strains so well known to occur around the crystals in porphyritic glassy rocks, which have recently been discussed by Mr. Rutley[1] and Mr. Waller,[2] there are other conditions of tension which affect much larger masses of natural glass, and which are comparable in the degree of their manifestation to those which are exhibited by the well-known Rupert's drops.

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[1] Geol. Mag. Dec. II. Vol. II. (1875), p. 308.

[2] See Phil. Mag. ser. 5, vol. viii. p. 25.

This condition of tension appears to be manifested in two different ways. In the case of the Marekanite-balls, and the obsidian from India described by Damour, the molecules are in a state of such unstable equilibrium that a jar, or an incision, is sufficient to bring about that partial re-arrangement which leads to their breaking up with more or less explosive violence. But in the case of the Ponza rock, the relief of newly-formed surfaces from strain leads to the separation of a thin, more or less wrinkled, film. A connection between these two cases is perhaps established by the experiment of submitting the Marekanite-balls to moderate heat, when thin white films like those formed spontaneously on the surfaces of the Ponza rock are seen to make their appearance.

The study of the mode of occurrence of these different rocks shows that the condition of extreme tension belongs to the nuclei of perlitic masses. It has long been recognized that the perlitic structure is the result of contraction in a rock-mass, and in 1879 it was shown by MM. Fouqué and Levy,[3] and in 1880 independently by Mr. Grenville Cole,[4] that this structure could be produced in colloid bodies by artificial means.

It has long been known that some of the natural glasses contain a considerable amount of water and other volatile substances, up to as much, indeed, in some cases, as 10 per cent. of their whole weight. It has often been asserted that the presence of a large percentage of water is characteristic of pitchstones, and of a much smaller amount of the obsidians. But the perfectly vitreous Marekanite-balls show by their behaviour when heated that they contain a very large proportion of volatile matter, and other similar exceptions to the supposed rule might be adduced. It is probably true that volatile matters are more likely to be retained within masses which have cooled down while subjected to the pressure of superincumbent material; and under the same conditions, that slower cooling would take place, which would lead to the more abundant development of crystallites and the acquirement of the mass of the resinous lustre characteristic of pitchstone.

Now, so far as my experience goes, the glasses containing a large amount of volatile materials have an abnormally low specific gravity. If the water be slowly separated from the mass, it is scarcely conceivable but that contraction should take place and the density rise. The materials in which the perlitic structure has been artificially produced—namely, precipitated silica and Canada-balsam—both contain volatile matters, and it is during the gradual removal of these in drying that the perlitic structure is produced. The spirally-curved cracks seen on the surface of American cloth in railway-carriages can be accounted for in the same way.

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[1] Quart. Journ. Geol. Soc. vol. xli. (1884), p. 340.
[2] Geol. Mag. Dec. III. Vol. II. (1885), p. 91.
[3] Mineralogie Micrographique (1879), pl. xix. fig. 2.
[4] Geol. Mag. Dec. II. Vol. VII. p. 115.

These and many other facts, which I will not now adduce, have led me to the conclusion that while the first series of straight cracks, which often produce columnar structures in rocks, owe their origin to the contraction which takes place during cooling, the secondary systems of curved cracks, which give rise to the perlitic and similar structures, are more probably due to the contraction which goes on as the volatile materials which they contain are slowly separated from them. I hope to adduce some further illustrations of this principle on a future occasion.

II.—ON CARBONIFEROUS OSTRACODA FROM THE GAYTON BORING, NORTHAMPTONSHIRE.

By Prof. T. RUPERT JONES, F.R.S., and JAMES W. KIRKBY, Esq.

(PLATE VII.)

THE Carboniferous Ostracoda here described are from the deep Gayton Boring, near Northampton. Hand-specimens of the rock, obtained by H. J. Eunson, Esq., F.G.S., were given to us by R. Etheridge, Esq., F.R.S., some months ago; and Mr. Eunson kindly gave us another piece lately.

To explain the situation of the bore, as well as the position of the Carboniferous strata in it, we quote as follows from Mr. H. J. Eunson's paper "On the Palæozoic Rocks beneath Northampton," in the Quart. Journ. Geol. Soc. vol. xl. 1884, p. 485, etc.:

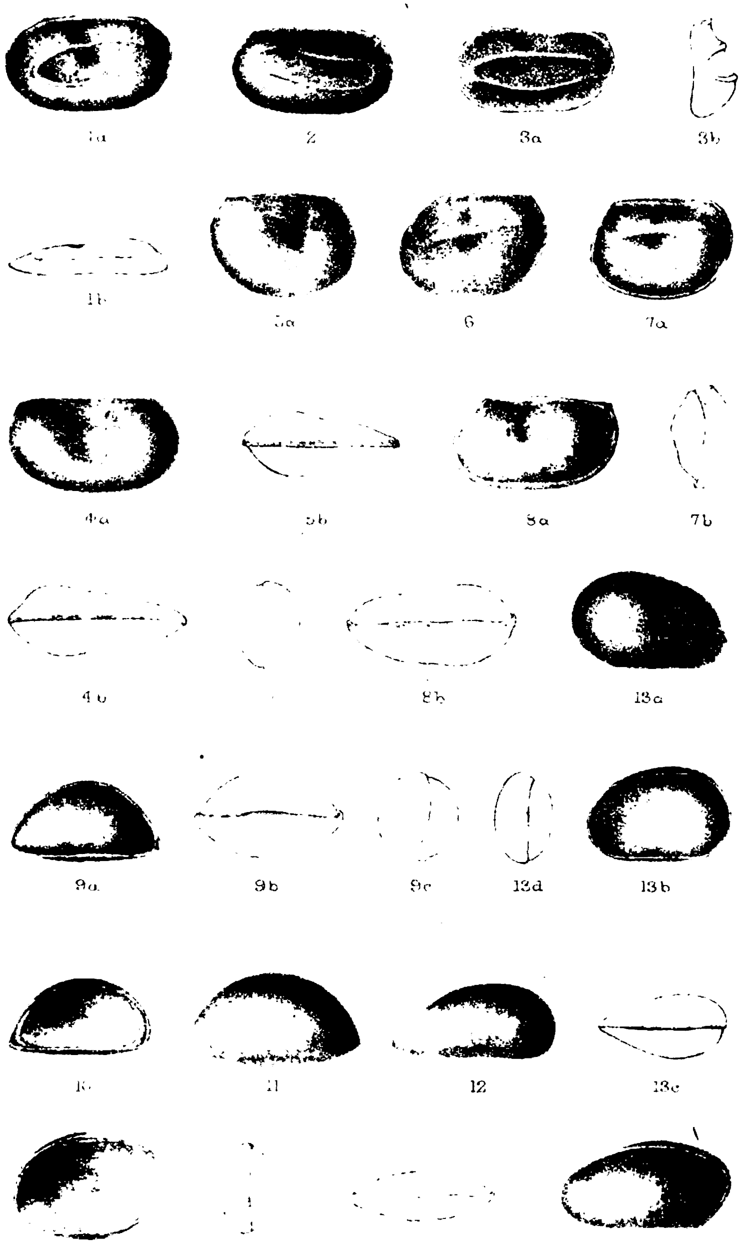
"The second trial took place near the village of Gayton, five miles south-west of Northampton, not far from the Banbury-lane crossing of the L. and N.-W. Railway, about two miles north-west of Blisworth Station (see Ordnance Map 52 S.W.). It was thought that, under the known attenuation of the Trias westward, the Waterstones could be found, if only the site selected was at a sufficient distance beyond the Carboniferous rocks to have allowed the lower beds of the Triassic series to be deposited near Northampton.

"This boring, 282 feet above sea-level, was commenced at the junction of the Upper with the Middle Lias, followed by the Lower Lias clays, the aggregate thickness of which was 581 feet."

The White Lias and Rhætic beds, 36 feet thick, are described as resting on a slightly eroded surface of the Triassic strata, which are 82 feet 6 inches thick. The lowest of these latter contained much *débris* of Carboniferous rocks. These last began, in the boring at 699 feet, with the eroded Carboniferous Limestone. From about 31 feet 6 inches lower down was brought up a bluish-grey shale; and from a little below that a greenish-grey shale. The former has yielded the little fossils here described. The latter contains similar Microzoa. The boring was continued into the Old Red Sandstone, and to a depth of 994 feet, without getting the supply of water sought for.

The minute specimens under notice were obtained for us by Mr. C. D. Sherborn by breaking and washing the rock in which they had been imbedded. There is a fair quantity of them,—certainly a few

Geol. Mag. 1886 Decade III. Vol. III. Pl. VII.



J W K del
E.C Knight lith

West Newman & Co. imp.

Carboniferous Ostracoda

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hundreds. The majority are single valves; and all of them are thick-shelled and have a robust appearance.

In the hand-specimens referred to we found—in the greenish-grey shale (at 731 feet), a few *Ostracoda*, and numerous fragments of calcareous organisms, chiefly of *Serpulæ*, some of Shells, and some possibly Encrinital:—in the bluish-grey shale (at 730 feet), many *Ostracoda*, besides numerous calcareous fragments as above.

In both shales the organic remains are crowded here and there along irregular planes and in other groups.

For the lists of fossils in the associated beds see Quart. Journ. Geol. Soc. Aug. 1884, pp. 487–8.

Remarks on the Species.

1. KIRKBYA VARIABILIS, sp. nov. Pl. VII. Figs. 4*a*, 4*b* (type); 5*a*, 5*b* (var. *a*); 6, 7*a*, 7*b* (var. *b*); 8*a*, 8*b* (var. *c*).

The prevailing form among this little group of Ostracods is a *Kirkbya* which has strong Beyrichian affinities. Some specimens of it are scarcely to be distinguished from such unisulcate species of *Beyrichia* as *B. arcuata* (Bean); but most examples show the valves ribbed after the fashion of *Kirkbya*, in which genus we place it.

It varies much in relative length and height; some specimens are nearly twice as long as high, others are only a fourth longer than high, while some, indeed, are nearly as high as long. What may be taken as the local typical form, being the most common, can be described thus:

Suboblong in outline, height rather more than half the length, dorsal border straight, ventral border convex, extremities rounded. The more compressed end, which we take as the anterior,[1] is more perfectly rounded than the posterior, which projects above, and is of less height than the other. Valves compressed in front, swollen behind, with a transverse subcentral sulcus; this is crossed by a strong longitudinal rib, which gives its lower portion the form of a subcentral pit; traces (more or less strong) of another and lower rib are usually present along the ventral convexity of the valve; and there is nearly always a narrow, sharp-edged rib near to, and almost parallel with, the dorsal margin. The valves are thick-shelled and the right is larger than the left, and overlaps it strongly along the ventral and extreme margins. Seen from above almost lanceolate in outline, with the greatest diameter behind. Surface smooth. Length $\frac{1}{30}$ to $\frac{1}{38}$ inch.

Var. *a*. Figs. 5*a*, 5*b*.

This is a shorter form, being only a fourth longer than high; with the ventral margin more convex, and with the posterior extremity much the highest. The sulcation and costal arrangement are the same, and the right valve overlaps the other, as in the type form.

Var. *b*. Figs. 6, 7*a*, 7*b*.

This variety is short and high, like that just noticed, but the carapace is fully as high at one end as the other, the curve of the posterior extremity forming a more obtuse angle with the ventral margin, which is but slightly convex. The general outline is thus more subquadrate than in the others.

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[1] This is the view we take now; but it was not followed throughout in a former paper on *Kirkbyæ*, Ann. Mag. N. H. March, 1885.

Var. *c*. Fig. 8.

This is very like *Beyrichia arcuata* (Bean) in appearance, and we were at first disposed to keep it apart from the present species, for it shows no indications of the two stout ribs along the centre of the valves, but it possesses the sharp dorsal rib or crest in full force. This latter feature, and similar ventral overlap by the right valve, together with the way in which the ribs become nearly obsolete in other examples of *variabilis*, cause us to group it with this species.

From the number of specimens of this species obtained from the shale of the boring, it would appear to have been of gregarious habit. Most of the specimens are single valves.

2. KIRKBYA PLICATA, Jones and Kirkby. Plate VII. Figs. 1*a*, 1*b*, 2, 3*a*, 3*b*.

K. plicata, J. and K. 1867, Trans. Geol. Soc. Glasgow, vol. ii. p. 221.

K. plicata, J. and K. 1885, Ann. Mag. Nat. Hist. ser. 5, vol. xv. p. 184, pl. iii. fig. 9, 10*a*, *b*.

Valves of this species are not rare among the Gayton Ostracods. They differ a little from typical specimens; their outline is more nearly oblong, the dorsal and ventral margins being almost parallel, and the ends nearly alike. The two longitudinal ribs that traverse the central portion of the valve are well marked, slope upwards posteriorly, and are looped together forward (in most examples). The subcentral pit or constricted sulcus is deep and placed anteriorly. One of the specimens shows a finely reticulated surface; all the others we have examined are smooth. The shell is thick; and the length about $\frac{1}{24}$ inch.

K. plicata is not a common species. It was first found in Carboniferous Limestone, at Backwell, Charterhouse, and Weston-super-Mare, in Somerset. It has not been noticed elsewhere in England. In Scotland it occurs at various localities of the Calciferous-Sandstone Series; and very rarely in beds in the lower portion of the Carboniferous-Limestone Series.

3. BYTHOCYPRIS SUBLUNATA, Jones and Kirkby, MS. Plate VII. Figs. 9*a*, 9*b*, 9*c*, 10, 11.

This is a species well known to us, though as yet undescribed. It was first sent us by Mr. James Bennie (Geological Survey of Scotland), in a washing of shale from Staneshiel Burn, Roxburghshire; also from another shale, at Tweeden Burn, in the same county. Both these localities are in the Calciferous-Sandstone Series. The species may be briefly described as follows:—

Carapace subtriangular or lunate in outline; tumid: with left valve overlapping the right all round. Dorsal margin boldly and almost evenly arched; ventral margin straight or slightly convex;

extremities pointed and nearly alike, though the posterior is rather the most acute; seen from above ovate, with the greatest diameter rather behind the centre. Within and a little below the margin of each valve a thin sloping ledge or plate projects inwards, and is most developed at the extremities (Fig. 10); surface smooth (finely polished in examples from Staneshiel Burn); shell thick; length $\frac{1}{30}$ inch.

We refer this species to *Bythocypris* doubtfully. The overlapping valve appears to be the left, but it is difficult to speak with decision on this point, both in this case as well as in some other Carboniferous species. Were the right valve the largest, then *Macrocypris* would apparently be the better genus in which to place it.

It is a comparatively common form among the Gayton Ostracods, occurring both as single and united valves. Individuals show some differences in relative length and height. Fig. 11 represents one of the longest of them, and rather suggests relationship with another Lower-Carboniferous species—*Argillæcia æqualis*, J. & K. MS.

Cythere? lunata, J. & K. (undescribed), from the Carboniferous Limestone of Holwell, Somerset, has some resemblance to the present species, though larger; and it may probably be a related form.

4. MACROCYPRIS JONESIANA, Kirkby. Plate VII. Fig. 12.

Bairdia Jonesiana (Kirkby), 1859. Ann. and Mag. Nat. Hist. ser. 3, vol. ii. p. 432, pl. xi. figs. 1, 2.

Fig. 12 represents a specimen that comes nearer to this species than anything else we know. The dorsal margin is not so regularly arched as in *B. sublunata*, the posterior slope being longer and flatter than the anterior; and the anterior extremity is broadly rounded, while the posterior is subacute. We refer it to *M. Jonesiana*, with some doubt.

5. CYTHERELLA EXTUBERATA, Jones and Kirkby. Plate VII. Figs. 13*a*, 13*b*, 13*c*, 13*d*.

Leperditia Okeni (Münster), var. *extuberata*, J. & K. 1880, Quart. Journ. Geol. Soc. vol. xxxvi. p. 588.

This species was discovered by one of us several years ago in the Calciferous Sandstones of Fifeshire. It was then considered to belong to *Leperditia*, and to be probably a variety of the common Carboniferous species, *L. Okeni* (Münster). This opinion was arrived at by a study of specimens imbedded in the matrix, only partially showing external characters, and by our taking the straight edge as the uppermost or dorsal margin.

Some years after this we received examples of the same fossil from our friend, Mr. James Bennie, who collected them from the Calciferous-Sandstone shale, at Staneshiel Burn, already mentioned. These specimens were, in many cases, single valves, finely preserved, showing the interior; and from these it is evident, owing to one valve being much larger than the other, and from it having an internal marginal groove for the reception of the smaller valve, that the species is more nearly related to *Cytherella*[1] than to *Leperditia*. To that genus then we refer it; and in doing so we consider that the convex edge is the back, thus bringing the large valve to the right hand, and the more compressed or narrowest half of the carapace to the front as the anterior portion, and so have it in harmony with what is to be observed in other *Cytherellæ*.

From the Gayton specimens we give the following provisional description, with the intention of noticing the species more fully on another occasion.

Carapace subovate in outline; dorsal margin arched and highest about the posterior third; ventral margin straight or faintly incurved; extremities rounded, the posterior obliquely so; the hinder third much higher than the anterior; the carapace is tumid and high behind, compressed and low in front. The left valve is much smaller than the right; not much more than half as high as long, while the right is two-thirds as high as long; the right valve overlaps the left round the whole of its margin. Viewed from above the profile of the carapace is subovate, widest behind, pointed in front. End view oval. It is rather thick-shelled; the surface is smooth. Length $\frac{1}{30}$ inch.

The only other English locality for this species is Skellygate, Northumberland, where it occurs in a shale of the Lower-Carboniferous Series.

6. CYTHERELLA ATTENUATA, Jones and Kirkby. Plate VII. Figs. 14*a*, 14*b*, 14*c*.

Leperditia attenuata, J. and K. 1880, Quart. Journ. Geol. Soc. vol. xxxvi. p. 588.

One or two examples of another form, also formerly referred by us to *Leperditia*, occur with the other specimens from Gayton. It is often found along with *C. extuberata* in Fife, and, like the latter, it probably belongs to *Cytherella*. Indeed, we are not sure that the relationship may not be closer to the species just described, for it is possible that the differences observed may be due to sex. These differences consist chiefly in the somewhat neater form of *attenuata*, in the less strong (though still complete) overlap of the right valve, and in the lateral contour, when seen from above, being more regularly lenticular, the ends being almost alike, and the greatest diameter being near the centre. In this latter character it certainly looks very different from *C. extuberata*, and for the present we leave it a distinct species.

There are thus six recognizable forms, or species, among the Ostracods from the Gayton Boring, namely—

Kirkbya variabilis, sp. nov.
K. plicata, J. and K.
Bythocypris sublunata, J. and K., MS.
Macrocypris Jonesiana (?), K.
Cytherella extuberata, J. and K.
C. attenuata, J. and K.

Five of these were previously known to us from other localities; and one, which is the most abundant, is new. Of the former, all of them are essentially Lower-Carboniferous forms, being most commonly found in the Calciferous-Sandstone Series of Scotland, and the more or less equivalent Carboniferous Limestone of England. Three of them, indeed,—*B. sublunata*, *C. extuberata*, and *C. attenuata*,—have not occurred above the Calciferous Sandstones; and the other two do not range higher than the lower portion of the Carboniferous-Limestone Series of Scotland; that is, speaking of the Carboniferous rocks only, for it should not be forgotten that *M. Jonesiana* is a Permian species.

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[1] See Monogr. Carbonif. Entom. Pal. Soc. 1884, p. 58.

EXPLANATION OF PLATE VII.

(The specimens are magnified about 25 diameters.)

Fig. 1–3. *Kirkbya plicata*, J. and K.; 1*a*, left valve; 1*b*, view of ventral edge; fig. 2, right valve; fig. 3*a*, left valve, showing reticulated surface; 3*b*, end view.

Fig. 4–8. *K. variabilis*, sp. nov.; 4*a*, carapace, right valve outwards; 4*b*, ventral view; 4*c*, end view; fig. 5*a*, carapace, right valve outwards; 5*b*, ventral view; fig. 6, left valve; fig. 7*a*, carapace, left valve outwards; 7*b*, end view; 8*a*, carapace, left valve outwards; 8*b*, ventral view.

Fig. 9–11. *Bythocypris ? sublunata*, J. and K.; 9*a*, carapace, right valve outwards; 9*b*, ventral view; 9*c*, end view; fig. 10, interior of left valve; fig. 11, left valve.

Fig. 12. *Macrocypris Jonesiana ?* Kirkby; right valve.

Fig. 13. *Cytherella extuberata*, J. and K.; 13*a*, carapace, right valve outwards; 13*b*, left valve; 13*c*, dorsal view; 13*d*, end view; 13*e*, interior of right valve. Fig. 13*e* is from Staneshiel Burn, Roxburghshire.

Fig. 14. *C. attenuata*, J. and K.; 14*a*, carapace, left valve outwards; 14*b*, ventral view; 14*c*, end view.

III.—On the Palæontology of the Selachian Genus *Notidanus*, Cuvier.

By A. Smith Woodward, F.G.S.,
of the British Museum (Natural History).

(*Continued from page* 217.)

Of the upper dental series, Probst[1] attempts to give a tolerably complete account, but it is only illustrated by very imperfect woodcuts. Two of the foremost awl-shaped teeth are figured by Lawley (*l.c.* figs. 2, 3), and the same author ascribes to the upper jaw of this species three other of the Pliocene specimens. Fig. 19 represents an anterior upper tooth from the Middle Eocene of Hampshire, and the original of Fig. 20 is another from the Miocene of Baltringen, Würtemberg. The former (B. M., P. 4707) exhibits a short thick base with an oblique principal cone, in front of which are a number of minute denticulations; posteriorly there is only one secondary cone, pointing sharply backwards, and about half the size of the principal cone; and this is followed by another small denticle. The second specimen (B. M. 35533) has also a short thick root, and shows a somewhat similar crown; the large principal cone is followed by one small secondary and a terminal denticle, and in front there are a few coarse serrations at its base. To a position somewhat further back in the upper jaw may also be referred the tooth represented in Fig. 21; this was obtained from the Red Crag of Woodbridge, and is preserved in the Reed Collection of the York Museum.

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[1] In his first paper ("Ueber das Gebiss des *Notidanus primigenius*, Ag.," *l.c.*): in 1879 the author expressed doubts as to the accuracy of his previous work, but it is not improbable that all the specimens at first figured may belong to the species under consideration.

N. primigenius is perhaps the most widely distributed of all the extinct species of the genus, and is especially noteworthy on account of its considerable size. It is much larger than *N. serratissimus*, and its lower teeth also differ from that species in having more secondary cones, and in possessing finer anterior serrations, which are not regular, but decrease from above downwards. With the exception of a brief notice by myself,[1] there appears to have been no record hitherto of the occurrence of the species in Britain, but, as already stated, the originals of three of the figures illustrating this description have been obtained from English deposits, and are derived from the Middle Eocenes of Barton and Bracklesham, and the Red Crag of Suffolk. It is not known to occur in the London Clay.

On the Continent there are numerous allusions to teeth of this specific type, from the Oligocene and Miocene, and the British Museum also contains specimens from the Eocene of Klein Spauwen, in Belgium. A single tooth has likewise been described by Gibbes from the Eocene of Richmond, in Virginia, and shows that this species extended into the New World in early Tertiary times: it would be unsafe at present, however, to regard all the notices of *N. primigenius* as correct determinations, although the analogy of other fossil sharks is far from rendering improbable so wide a range in time and space as has already been assigned to it. Winkler mentions specimens from the Middle Oligocene of Belgium; Rouault and others record the species in France; Orueta in Spain; Adams in Malta; Lawley in Italy (Pliocene); and the references to German specimens are far too numerous to mention.

15. N. REPENS, Probst.

1879. *N. repens*, J. Probst, Württb. Jahresh. vol. xxxv. pp. 163-166, pl. iii. figs. 18-22.

Founded upon some small teeth from the Miocene of Baltringen, Würtemberg. The cones are all extremely low, and were perhaps eight in number in the lower teeth, with large anterior serrations: the specific identity of all the specimens figured appears somewhat doubtful.

16. N. BISERRATUS, Münster.

1842. *N. biserratus*, Graf von Münster, "Beitr. Petref." pt. v. p. 66, pl. xv. fig. 9.

This species was founded upon a small tooth from the Oligocene of Neudorft in the Vienna Basin, but does not appear to have been recorded since its original description. The principal cone is about four times the size of the largest of the secondary cones, and the latter are no less than twelve in number. The eight anterior cones are distinctly serrated on both edges.

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[1] Smith Woodward, "Chapters on Fossil Sharks and Rays.—II.," Science Gossip, vol. xx. (1884), pp. 229, 230.

17. N. Loozi, Vincent.

1876. *N. Loozi*, G. Vincent, Ann. Soc. Malacol. Belgique, vol. xi. p. 126, pl. vi. fig. 5.

I am indebted to Mr. G. F. Harris for the reference to M. Vincent's description of a fragmentary tooth of *Notidanus* under the specific name of *N. Loozi*. The specimen in question was obtained from the Lower Landenien (Thanet Sand) of Belgium, and exhibits nothing beyond the anterior portion of the crown: it indicates a species about the size of *N. primigenius*, and it is distinguished from the tooth of this well-known form by the peculiar shape of the cones, and the very large denticulations in front. Notwithstanding its imperfect character, the type-specimen appears to justify the author's conclusions.

18. N. Targionii, Lawley.

1877. *N. Targionii*, R. Lawley, Atti Soc. Toscana Sci. Nat. p. 71, pl. ii. fig. 3.

A small species founded upon lower teeth from the Pliocene of Tuscany. The type specimens are evidently very similar to the mandibular teeth described above as immature examples of *N. serratissimus*.

19. N. gigas, Sismonda.

1857. *N. gigas*, E. Sismonda, Mem. R. Accad. Sci. Torino, ser. 2, vol. xix. p. 460, fig. 13.
1877. ,, ,, R. Lawley, Atti Soc. Toscana Sci. Nat. p. 68, pl. i. fig. 6.

A species allied to *N. primigenius*, but with the lower teeth relatively longer, the cones less regular, and the anterior serrations of the crown more pronounced. Occurs in the Miocene of Mondovi, Piedmont, and the Pliocene of Volterrano, Tuscany.

It is interesting to be able to add that teeth undoubtedly referable to this species have also been obtained from the Pliocene of Britain. Through the kindness of Mr. Reed, the Hon. Curator in Geology, and Mr. Noble, the Hon. Secretary, of the York Museum, I have had the opportunity of examining the beautiful series of Crag Notidanidæ in the Reed Collection of that institution, and among these there is a very perfect crown of *N. gigas*, shown in the accompanying woodcut (Fig. 1). The specimen has been considerably rolled and abraded, so that the anterior serrations are scarcely visible, and the root is wanting, but it is otherwise a most typical example. An upper side tooth in the same collection may also perhaps be associated with this form.

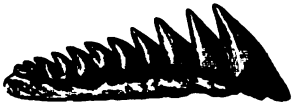

Fig. 1.—Tooth of *Notidanus gigas*, Sismonda. Red Crag, Suffolk. [Reed Coll., York Museum.]

20. N. Meneghinii, Lawley.

1877. *N. Meneghinii*, R. Lawley, Atti Soc. Toscana Sci. Nat. p. 72, pl. ii. fig. 4.

Some large mandibular teeth from the Pliocene of Volterrano, Tuscany, have been described by Lawley under this specific name.

The principal cone is relatively large, and is followed by ten to twelve secondary cones; at its base the enamel of the crown extends far down upon the root, and the long anterior border thus produced is strongly serrated for quite two-thirds of its extent.

A tooth of this species from the Red Crag of Woodbridge is also preserved in the Reed Collection of the York Museum. It is shown of the natural size in the woodcut (Fig. 2). An anterior upper tooth from the Red Crag of Bawdsey is also perhaps referable to the same form.

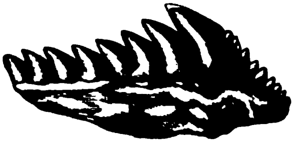

FIG. 2.—Tooth of *Notidanus Meneghinii*, Lawley. Red Crag, Suffolk. [Reed Coll., York Museum.]

21. N. D'ANCONÆ, Lawley.

1877. *N. D'Anconæ*, R. Lawley, *loc. cit.* p. 73, pl. iii. figs. 1, 2.

A small species. The teeth consist of four to six acute cones, the first or principal cone being very large compared with the others, and the anterior edge is serrated for a considerable length. It is a rare form in the Pliocene of Volterrano and Orciano Pisano, Tuscany; and Probst[1] also describes some teeth from the Miocene of Baltringen, Würtemberg, under the same specific name, but this is a very questionable determination.

22. N. PROBLEMATICUS, Lawley.

1877. *N. problematicus*, R. Lawley, *loc. cit.* p. 74, pl. iii. figs. 3, 4.

This is a very doubtful species founded upon an upper tooth from the Tuscan Pliocene, and merely named—as the author states—to call attention to the peculiar specimen figured.

23. N. ANOMALE, Lawley.

1877. *N. anomale*, R. Lawley, *loc. cit.* p. 74, pl. iii. fig. 5.

If the mandibular tooth figured by Lawley as the type of this species is genuine—as seems probable, notwithstanding the fracture across its middle—it represents the largest member of the genus hitherto recorded. There are no less than 14 secondary cones, and the tooth measures more than five centimetres in total length. The principal cone and the three following are curiously contorted—though it is possible that this may be an abnormal condition—and the anterior edge of the first is strongly denticulated. An upper tooth is also figured (pl. iii. fig. 6) which may perhaps belong to the same form. Both are from the Pliocene of Tuscany.

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[1] J. Probst "Beiträge zur Kenntniss der fossilen Fische aus der Molasse von Baltringen," Württb. Jahresh. vol. xxxv. (1879), pp. 166—169, pl. iii. figs. 6—11.

Such is a brief enumeration of the various specific types of fossil Notidanidæ that have hitherto come under my notice. One other form has also been assigned to this genus by Winkler,[1] under the name of *N. Orpiensis*, but this is apparently an erroneous determination: the type-specimens are from the Thanet Sand (Heersien) of Orp-le-Grand, Belgium, but only one (*l.c.* fig. 15) seems referable to *Notidanus*, and that is too imperfect to name specifically.

And now, in conclusion, there are one or two general considerations suggested by the foregoing facts to which it may be interesting briefly to refer. On examining the various forms of teeth in stratigraphical order, it is at once evident that there are distinct traces of specialization. In the earliest Jurassic types hitherto known, with a single exception (*N. serratus*), the secondary cones are only two, three, or four in number, while most members of the genus of Cretaceous and Tertiary age possess at least six or seven in the lower teeth, and one Pliocene species (*N. anomale*) has been recorded with no less than fourteen: it is also noteworthy that some of the Jurassic teeth are characterized by the absence of anterior serrations on the principal cone. Again, it is interesting to observe that the very deep compressed fibrous root of the more recent Notidanidæ only began to assume its peculiar characters towards later Cretaceous times, the base in such species as *N. serratus* and *N. Daviesii* being comparatively thick and depressed, and very suggestive of that of *Hybodus*. The earliest species of *Notidanus*, indeed, have teeth so remarkably similar to those of certain Hybodonts, that not only did Phillips—as already stated—figure two specimens under the name of *Hybodus polyprion*, but at least one other palæontologist[2] appears to have made the reverse mistake. A careful study of a large series of specimens of the well-known Stonesfield species results in the discovery of some teeth that may almost be regarded as links between the two. The originals of Figs. 1, 2, Pl. VI., for example, are such forms as would be commonly associated with *Hybodus polyprion*, but a very slight modification is necessary to convert them into most typical Notidanidæ, and I have considerable doubts as to the propriety of placing them with *Hybodus* at all. To transform a long-coned Hybodont tooth into one of *Notidanus*, it is only necessary to assume lateral compression and the reduction or loss of the anterior secondary cones, and the teeth represented in Figs. 1 and 2, Pl. VI., exhibit a marked approach to this condition. Fig. 1 shows a large, compressed principal cone, preceded by four secondary cones, and followed by two others, the former being reduced to quite small denticles, while the latter are comparatively well developed: the front edge of the principal cone is distinctly denticulated for half its length, and so also is the first secondary; and there are traces of vertical wrinkles at the base of the crown. Fig. 2 is a smaller but very similar tooth, and the characters of both these specimens are such that they might well be looked upon as closely allied to ancestral Notidanidæ, even if not actually upon the main line of descent of this family.

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[1] T. C. Winkler, "Mémoire sur quelques Restes de Poissons du Système Heersien," Archiv. Mus. Teyler, vol. iv. fasc. i. pp. 12, 13, figs. 13–17.

[2] E. Favre, "Description des Fossiles du Terrain Oxfordien des Alpes Tribourgeoises," Mém. Soc. Paléont. Suisse, vol. iii. (1876), p. 16, pl. ii. fig. 1. The tooth is described as *Notidanus* sp., but the figure agrees much more closely with that of a species of *Hybodus*.

Another interesting fact worthy of consideration is the distinct evidence of wear already noted in the dentition of the *N. eximius* of Schnaitheim (p. 210); it is impossible to conceive of this taking place in Sharks that have the teeth so loosely attached to the jaw, and so frequently replaced as are those of the living Notidanidæ, Lamnidæ, Carchariidæ, etc., and I have never observed the peculiarity either in the Recent, Tertiary, or Cretaceous forms. The circumstance is very suggestive, indeed, of the oldest Notidanidæ having the teeth as firmly implanted as those of the Hybodonts, in which there were two or more rows in function at a time, and in which also the longest cones often show most evident traces of abrasion. The shape of the root is quite in accordance with this supposition. It is proper to add, however, that I have met with no very decided abrasion among the large series of British Museum specimens of *H. polyprion*, which seem most nearly to approach *Notidanus*, although this fact may be partly accounted for by the considerable rolling to which many of the teeth have been subjected before entombment in the Stonesfield Slate; the cones of the Carboniferous *Cladodus* are often much worn down, and so likewise are those of the long-coned species of *Hybodus* in the Muschelkalk.

As to the precise significance of these various points of similarity between the Hybodonts and the primitive Notidanidæ, it would be unsafe at present to express any definite opinion. Except in the structure of the skull, which is very similar,[1] the latest members of each family exhibit many important differences. The Hybodonts have two (spinous) dorsal fins, and at least since Jurassic times the Notidanidæ have possessed only one; in the last of the Hybodonts, moreover, there are well-calcified vertebræ, while so advanced a stage is far from reached in the living Notidanidæ. I have likewise been able to determine that the Wealden species of *Hybodus* only possessed five branchial arches; and there are also other points of divergence to be taken into account. When, however, more is known of the anatomy of the earliest Mesozoic forms, it may still be possible to show that the evidence of the teeth is not altogether misleading, but that even if the Notidanidæ are not an early offshoot of the Hybodontidæ, they are at least derived from the same primitive stock.

EXPLANATION OF PLATE VI.

Fig. 1. Tooth commonly referred to *Hybodus polyprion*, Ag. Great Oolite, Bath. B.M. (P. 2186.)

„ 2. Tooth commonly referred to *Hybodus polyprion*, Ag. Great Oolite, Stonesfield. B.M. (35494.)

„ 3. *Notidanus eximius*, Wagn.; lower tooth. Corallian, Schnaitheim. B.M. (35763.)

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[1] Smith Woodward, "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*, Mackie)," read before the Zoological Society, April 20th, 1886.

Fig. 4. *Notidanus eximius*, Wagn.; lower tooth, outer view. Corallian, Schnaitheim. B.M. (35763 *a*.)
„ 5. *Notidanus eximius*, Wagn.; upper tooth, inner view. Corallian, Schnaitheim. B.M. (22500.)
„ 6. *Notidanus sp.*; upper tooth, outer view. Corallian, Schnaitheim. B.M. (22502.)
„ 7. *N. serratus* ? Fraas; upper tooth, outer view. Oxfordian, Scarborough. B.M. (35667.)
„ 8. *N. Daviesii*, A. S. Woodw.; lower tooth, outer view. Oxfordian, St. Clement's. Oxford Museum.
„ 9. *Notidanus sp.* Oxfordian, St. Clement's. Oxford Museum.
„ 10. *N. microdon*, Agass.; anterior upper tooth, outer view. Chalk, Norwich. B.M. (24927.)
„ 11. *N. microdon*, Agass.; upper tooth, outer view. Chalk, Sussex. B.M. (4164.)
„ 12. ,, ,, ,, ,, ,, ,, Kent. B.M. (44580.)
„ 13. ,, ,, lower ,, ? inner ,, ,, Norwich. B.M. (24928.)
„ 14. ,, ,, ,, ,, outer ,, ,, ,, B.M. (35648.)
„ 15. ,, ,, ,, ,, ,, ,, ,, ,, B.M. (48950.)
„ 16. *N. lanceolatus*, A. S. Woodw.; upper tooth, inner view. Gault. B.M. (P. 1227.)
„ 17. *N. dentatus*, A. S. Woodw.; upper tooth, outer view. L. Greensand, Amuri Bluff, New Zealand. B.M. (P. 2303.)
„ 18. *N. dentatus*, A. S. Woodw.; lower tooth. outer view. L. Greensand, Amuri Bluff, New Zealand. B.M. (P. 2303 *a*.)
„ 19. *N. primigenius*, Agass.; anterior upper tooth, inner view. M. Eocene, Hampshire. B.M. (P. 4707.)
„ 20. *N. primigenius*, Agass.; anterior upper tooth, outer view. Miocene, Baltringen. B.M. (35533.)
„ 21. *N. primigenius*, Agass.; anterior upper tooth, outer view. Red Crag, Woodbridge. Reed Collection, York Museum.
„ 22. *N. primigenius*, Agass.; lower tooth, outer view. M. Eocene, Barton Cliff. B.M. (P. 1224.)
„ 23. *N. serratissimus*, Agass.; tooth, outer view. London Clay, Sheppey. B.M. (24618.)
„ 24. *N. serratissimus*, Agass.; young tooth, outer view. London Clay, Sheppey. B.M. (28890.)
„ 25. *N. serratissimus*, Agass.; lower tooth, young, inner view. London Clay, Sheppey. B.M. (30560.)
„ 26. *N. serratissimus*, Agass.; lower tooth, young, inner view. London Clay, Highgate. B.M. (43133.)

[B.M. = British Museum. All the figures are of the natural size.]

IV.—On the District of the Ancient Glaciers of the Isar and of the Linth.

By Prof. Albert Heim, of Zurich, and Prof. Albrecht Penck, of Vienna.[1]

In order to interchange our views, and arrive at a common understanding on the question of the connection of glaciers with the formation of lakes, we undertook a joint excursion in Upper Bavaria, in the district of the Ammer Lake, Wuerm Lake, Staffel Lake, and Rieg Lake, and later, in the month of September, we visited together the shores of the Lake of Zurich, partly accompanied by Dr. K. I. V. Steenstrup, of Copenhagen, Dr. A. Wettstein and Dr. E. Brueckner, of Hamburg. We have drawn up a short protocol, both on the facts observed and of our views respecting them, which we here propose to communicate.

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[1] Translated from the authors' MSS., by Dr. G. J. Hinde, F.G.S.

I.—*The Division of the Quaternary Formation in the District of the Highland Lakes of Bavaria.*

Throughout the lake district of Upper Bavaria, the basement bed is everywhere formed by the "Flinz" (Upper Miocene Clay, Marl, and Clayey Sandstone), on which rest the Quaternary beds, which are briefly characterized below.

(*a.*) A layer of Conglomerate (Nagelfluh) from 20 to 30 mètres in thickness, having a nearly even surface, and rising with remarkable uniformity in a gentle slope towards the S. and S.W. It consists of pebbles of limestone and dolomite, and contains very few erratics of Archæan rocks. The material is fairly evenly rounded, and united by a calcareous cement. Hollow boulders and decayed pebbles are abundant in it.

(*b.*) A deposit of gravel which may readily be distinguished from the Conglomerate (*a*) or "Deckenschotter," by the greater irregularity in the size of the pebbles, and the far greater abundance of pebbles of Archæan rocks. It is seldom cemented into a conglomerate, it contains no hollow boulders, but there are in it rolled fragments of the diluvial Nagelfluh mentioned above (*a*). This gravel deposit is the Lower "Glacialschotter" of Penck (Die Vergletscherung, etc., p. 142). It is also of great uniformity and is widely distributed. Its general dip from south towards the north is less than that of the diluvial Nagelfluh (*a*), so that in the lake district to the south it is deposited lower on the slopes of the valleys (which consist of Miocene Flinz) than the Nagelfluh (near Weilheim 100 m.), whilst towards the north, near Munich, it overlies the Nagelfluh.

Here, in the Isar Valley above Grosshesselohe, an intermediate, independent deposit of gravel (intermediate Schotter, Penck, Die Vergletscherung, p. 290) is interposed between the Nagelfluh and the Lower Glacialschotter, which has not yet been noticed in the lake district.

(*c.*) An irregular covering of genuine morainic material, swelling up in places into hilly ridges, extends in the lake district, in a very discordant manner, as well over the elevations occupied by the Nagelfluh, as over the Miocene Flinz, and the slopes of the diluvial gravels (*b*), up to the foot of the hills. Only in the district of the outer moraines (near Fürstenfeld-Bruck, etc.), are the diluvial gravels (*b*) and the slopes of Flinz free from this morainic covering.

The moraines show nearly the same admixture of pebbles as the gravels (*b*). They contain scratched boulders, together with angular fragments of the same kinds of rock. All these scratched and angular fragments are usually small, they very seldom reach a diameter of half a mètre, generally they vary from the size of a nut to that of one's fist. This type which is characteristic of the ground-moraine is particularly represented also by the longitudinal ridges. Therefore the latter may be recognized as the ground-moraine scooped out at the margin of the ancient glacier.

In the district embraced in our excursion, no moraines are present at the base of the Nagelfluh or below the glacial gravels (*b*). Below these latter, however, beyond the excursion district, near

Toelz, Laufen on the Salzach, and at Stefansbrücke near Innsbruck, Penck has discovered moraines; but at the base of the Nagelfluh, Tertiary strata exclusively have been met with.

Where we met with recently exposed surfaces, showing the deposition of the moraine on the diluvial Nagelfluh (at Tutzing, Berg, Starnberg), the surface of this latter was smoothed and polished as distinctly as if it had been a homogeneous rock, and striated in the same direction as the course of the valley. The individual pebbles in the Nagelfluh were also evenly cut through in section.

Also when the contact surface of the moraine and the glacial gravels (*b*) was exposed, there was nearly always a sharply-marked, often discordant, boundary between the two deposits, without disturbance in the underlying gravel; and occasionally the projecting boulders in the gravel were striated in the direction of the valley, though no connected striated surface had been formed on them.

North of the Starnberg Lake, we noticed a moraine irregularly interpenetrated with beds of gravel and sand; which we recognize as a deposit formed near the terminal end of a glacier (Penck, Vergletscherung, etc. p. 132, figs. 4, 5).

II.—*The Quaternary Deposits in the District of the Lake of Zurich.*

In the valley of the Lake of Zurich, as in the lake district of Upper Bavaria, Upper Miocene strata form the foundation on which the Quaternary deposits rest, and these latter are also divided into gravels (Schotter) and moraines.

In contrast, however, to the exceptional regularity with which the gravel deposits in the Bavarian lake district succeed each other under the moraines, those at the lower end of the Lake of Zurich show, on the one hand, an extremely slight connected development, and on the other, they present such great differences in regard to the respective elevations at which they are deposited, that it seems almost impossible definitely to mark out their limits, or to parallel the deposits of different localities.

(*a.*) There is indeed found occasionally, on certain particular elevations between the valleys, a deposit of Nagelfluh, resembling petrographically the Bavarian diluvial Nagelfluh (Uetliberg 870 m., Baden 470—490 m., Sihlsprung near Hirzel [outside the bounds of our united excursion] 580—640 m.); but this is so limited in its distribution, and the places in which it appears are so far apart, that, with our present knowledge, it cannot be considered as the remains of a general covering. Besides, moraines occur under the cavernous Nagelfluh of the Uetliberg, whilst they have never been met with below the Bavarian diluvial Nagelfluh, and on the other hand moraines do not any longer appear above this Nagelfluh as they do in that of Bavaria. The cavernous Nagelfluh of Sihlsprung near Hirzel rests, according to Heim, on ground-moraines, and is covered by immense upper moraine deposits.

(*b.*) A somewhat different formation of loose gravels (Schotter) and Nagelfluh, either with or without decayed pebbles, is present, though in very few localities, on the slopes of the valley of the Lake of Zurich (Waedensweil, Utznach). We find similar gravels and Nagelfluh far wider distributed at the north-east border of the Glatt Valley, where they lie between the ground-moraine and the upper-moraine. Near Dürnten and Wetzikon, lignites are deposited between the gravel and the ground-moraine. These deposits of rolled materials also, which we here place under (*b*), are isolated to such an extent, and deposited at such different heights, that they cannot be regarded, at least so far as the valley of the Lake of Zurich is concerned, as the remains of an extended connected valley deposit.

(*c.*) The Nagelfluh of the Au peninsula, on the Lake of Zurich, is distinguished by its "delta structure" from the above-mentioned deposits of rolled materials in the neighbourhood of the Lake, and it has no equivalent in our Bavarian excursion-district. It calls to mind the ancient Kander delta, on the Lake of Thun, and according to Penck (Vergletscherung, etc., p. 343), the Nagelfluh of Biber in the Inn valley, and that of the Mönchsberg of Salzburg. Its relation to the moraines is not exposed. From the mode of its occurrence it very probably belongs to the base of the upper moraine.

(*d.*) Of all the Quaternary deposits, the moraines of the Lake of Zurich play the most important part. There is an astonishing contrast between them and the typical Bavarian moraines. The morainic hills are shown by the prevalence of large, angular, erratic blocks and sand, and the diminished quantity of clayey material, to belong mostly to the upper-moraines; such are altogether absent in the Bavarian lake district. The pure ground-moraines form in Switzerland an irregular, but not very thick layer, overlaid by the upper-moraines, or by the gravelly deposits above mentioned. Only the terminal moraines, and not the longitudinal moraines, have obtained a great part of their materials from the ground-moraines.

III.—*The Relation of the Upper Bavarian Lakes to the Quaternary Deposits.*

The Ammer Lake and Wuerm Lake occur in wide valleys, which form deep bay-shaped indentations in the southern margin of the same deposit of Nagelfluh. In the valleys especially, which have been excavated in the deposit of Nagelfluh, and also in the surrounding district of the above-named lakes, the gravels (I. *b*) are developed, and, indeed, they can be seen with constant characters, in the lower part of both lakes, in the upper part of Ammer Lake, and on the east margin of Wuerm Lake. The Lakes of Staffel and Rieg are situated to the south of the Nagelfluh district, where they extend themselves in a basin in the ancient Molasse, which is partly filled with the gravels I. *b*. (Schotter). They are bounded above and below by ridges of the dislocated Molasse, whilst between both only horizontal beds of the gravels (I. *b*) are raised above the surface.

The moraines form a surface layer, alike on the tops of the hills between the lakes, as on their slopes down to the margins of the lakes, thus, as a rule, covering discordantly the outcrops of Nagelfluh, Miocene Flinz and gravel (I. *b*); so that these various deposits are only exposed in lateral gullys or in steep cliffs.

Ammer Lake and Wuerm Lake are limited above and below by recent deposits. Their valley basins are bounded below by moraine walls, which the outflow from the lake cuts through, forming extremely narrow valleys. In the sections laid bare, the gravel (*b*) is shown under the moraine, and in the Wuerm Valley the Flinz is also exposed. Lower down the valley, beyond the moraine walls bounding the lake-basins, the gravel (I. *b*) forms extended terraces, partly interrupting the covering of the Nagelfluh and the outer moraine.

IV.—*The Relation of the Lake of Zurich to the Quaternary Deposits.*

Wuerm Lake and Ammer Lake, both in their relation to the Quaternary deposits, and also to the Molasse valley to which they belong, show very different phenomena to those of the Lake of Zurich and of the other large lakes of the Alpine borderland of Switzerland. The valleys in the Molasse in these latter are much deeper. A deposit like the gravel (Schotter) (I. *b*) in Bavaria, which both above and below the lakes exhibits the same uniform slope, is altogether unknown in the Lake of Zurich, in which the only gravels found are those mentioned under (II. *b*). On the declivities of the valley of the Lake of Zurich, the Molasse rock is itself carved into distinct erosion terraces, independent of the stratification, and these are often only sparsely covered with glacial *débris*, and not seldom altogether bare, whilst a similar condition of things is not observable on the borders of Wuerm Lake and Ammer Lake on account of the slight elevation of the outcrop of the Flinz and of the valley slopes, and of the soft character of the material. In Switzerland, for the most part, the valleys below the lake basins remain widely open, and show more especially the characters of main lines of ancient valleys. Hardly anywhere is the outlet of a lake through a narrow gully. The Molasse in the district of the Lake of Zurich is plainly not horizontal, but it forms a shallow trough between the Alps and Jura: the depression in this has affected the ancient erosion-terraces in unequal proportions.

The Quaternary deposits rest on the dislocated Molasse terraces of the declivities of the valley, so that the lateral moraines, with their somewhat steeper inclinations in the direction of the valleys, cut the margins of the Molasse terraces at an oblique angle.

On the other hand, Rieg Lake and Staffel Lake in some measure call to mind certain of the smaller lakes of the Alpine borderland, as, for example, Greifen Lake and Pfaeffikon Lake in the Glatt district.

V.—*The Question of the Origin of the Lake-Basins.*

In our excursion in Upper Bavaria, Heim had the opportunity of ascertaining the facts respecting this district published by Penck in his "Vergletscherung der deutschen Alpen." [1] On the other hand, Penck was able to confirm the facts which had been published by A. Wettstein in his work, "Geologie von Zürich und Umgebung." We are completely agreed respecting the facts observed, and differences can only arise on the conclusions to be drawn from the facts. The great differences in the Quaternary deposits of Bavaria and of Switzerland deserve special prominence. They teach that the greatest prudence is necessary, in regard to generalizations based on conclusions drawn from a limited area.

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[1] A review of this work is in the GEOLOGICAL MAGAZINE for 1883, Decade II. Vol. X. p. 177.

The grounds which Penck brings forward in favour of the Glacial origin of the Bavarian highland lakes are:—(1) the coincidence of the position of the lakes with the glacial deposits; (2) the characters of the lake valleys are such as are produced by erosion; and (3) the age of the lakes.

Their character as products of erosion is made clear from the fact that they are valley-shaped gaps in a continuous uniform series of undisturbed stratified gravels, whilst their diluvial age is proved by the fact that these stratified gravels end with the deposit of the diluvial Nagelfluh (I. *a*). On the other hand, both above and below the lakes, as well as round their margins, the horizontally stratified gravels (Schotter) (I. *b*) are shown, in which the lake-basins appear to form excavations. As these gravels (I. *b*) are, on the one hand, covered by moraines, and on the other, contain a notable number of pebbles of Archæan rocks, which could only have been transported by glaciers from the central region of the Alps over the passes of the limestone Alps, they must therefore have been formed immediately before the advance of the glacier into the lake district. As, however, the lake-basins are excavated in these gravels, they are necessarily more recent; they could thus not have yet been in existence at the commencement of the last glaciation of this district to which the gravels correspond. On the other hand, the deposition of the moraines on the slopes of the lake-basins shows that these latter were formed at the time of the retreat of the glacier. Their origin must therefore have taken place at the time of the glaciation itself.

Of these three grounds brought forward by Penck, the first one is established. As regards the second, it might be said that the gaps in the south margin of the covering of Nagelfluh might have been produced in it originally; that glacial-tongues, which covered the areas of the lake-basins, produced the Nagelfluh, as a fluvio-glacial deposit, whilst they protected the lake-basins against the accumulation of gravels. Against this, is,

(*α*.) The high degree of uniformity in the petrographical characters and the stratigraphical deposition of the Nagelfluh (I. *a*).

(*β*.) The absence of any morainic material below the Nagelfluh, as also the non-existence of genuine glacial materials, such as striated boulders, etc., within it.

A further possible mode of formation of the lakes might consist in a relatively small change of level in the lake district, by which the original slope of the Nagelfluh was diminished, whilst the valleys cut in it became reversed, and converted into lake-basins. This is the more conceivable, since the southern part of the covering of Nagelfluh has a somewhat steeper dip than the more northern part; this, however, may readily be regarded as its original structure.

A positive proof of such changes cannot be found in the oldest deposits of the district of the Bavarian highland lakes, which thus contrast with those of the Lake of Zurich, because connected erosion-terraces are wanting, and more especially because the position of the strata of the Miocene Flinz cannot be accurately determined. But though the possibility of such an origin of the lakes through local changes of level cannot be proved to be inconceivable, it is so, nevertheless, if it leaves the coincidence of the extension of the glacier with the formation of the lakes, and the absence of lakes beyond the margin of the glacier, to be explained as the result of pure chance.

As regards the third ground for the glacial origin of the Bavarian highland lakes, *the age of the lake-basins*, it may be remarked that the gravels (I. *b*) are deposited on the slopes of Nagelfluh and Flinz. As the gravels were formed before the advance of the glacier, the valley which they cover, as well as the gaps in the covering of Nagelfluh, must also have been in existence *before* the glacier, as, moreover, Penck has already noticed (Vergletscherung, p. 357). There remains, therefore, no further solid excavating work for the glacier to perform, but merely the re-excavation of a part of the old valley out of the gravels (I. *b*), leaving behind many fragments of the same on the slopes, and further, the scooping out of the hollow, 120 m. in depth, in the soft Flinz. It may be noticed that the Flinz is a marly-clay which falls to pieces in water, and although rock in appearance, it would offer less resistance to the course of the glacier. than even loose pebbles.

Staffel Lake and Rieg Lake lie between ridges of Molasse, parallel to the Alps. The oblique partition separating them is formed of huge masses of the gravels (I. *b*), which can hardly have been originally deposited in their present limits. Heim acknowledges, in view of this, that a re-excavation of a part of the gravels in the same northerly direction in which the Alpine valleys become open, is by far the most probable mode of the formation of these lakes. Heim also accepts a similar origin for the now extinct lake of Murnau and the lake Kochel. As, however, regarding these lakes, it is only a question of the re-excavation of basins of dislocation, in which the harder ridges of Molasse on their margins and the islands of the same have *not* been destroyed, we are both entirely of the same opinion respecting them.

On a consideration of the Bavarian highland lakes, Heim conceives the re-excavation of valleys filled with loose gravels, as also the scooping out of depressions in very yielding materials, and thereby the formation of lake-basins through glaciers, possible, as heretofore (comp. "Gletscherkunde," p. 382 at top, and p. 386), and in the present instances, as very probable. On the contrary, proofs of the formation of extended basins in hard rock and of the excavation of the same through glaciers cannot be found in this district.

Of the three grounds, which, according to Penck, support the glacial origin of the Lakes of Ammer, Wuerm, Rieg, and Staffel, only the two former are applicable to the Lake of Zurich, and the other large lakes of the Swiss Alpine borderland. But just as little as in the first case, the position of the lakes in the area of glacial deposits, and, in the second, the character of the lake valleys as produced by erosion, can be disputed, even so little can the age of the lakes be brought forward as a proof of their origin.

Whilst namely, on the one hand, the gravel deposits indicated by II. *a* and II. *b* are only thus locally and sporadically developed, so that no conclusion can be at present arrived at as to their former connection, it can neither be proved that the lake valleys are depressions in a former covering of diluvial Nagelfluh, nor that the lake-basins represent hollows in a gravel formation corresponding to I. *b*. There is thus nothing to add to our information respecting their Quaternary, *i.e.* Glacial age. But, on the other hand, the Nagelfluh of the Au represents a probably very ancient deposit, which, by its delta structure, proves the existence of the Lake of Zurich already previous to the commencement of the last glaciation, so that the lake cannot be attributed to its action. At the same time, the position of the rock-terraces of the declivities of the valley afford decisive proof of dislocations which affected the lake valley and produced the basin-shaped depression in it. Penck holds with Heim and Wettstein that there is undeniable evidence of the influence of dislocations in the formation of the basin of the Lake of Zurich, but he is nevertheless of the opinion, that with a more thorough investigation of the Swiss Quaternary gravel deposits, it may perhaps be found possible to discover a parallel between the deposits named I. *b* and II. *b* in the two areas respectively, and he holds the view that the lake-basin originally produced by dislocation may be to a greater or lesser degree excavated by glacier action. Heim also does not question the fact of a certain, though relatively small, amount of the scooping out of the lake-basin being due to the glacier.

Penck holds that to re-excavation may very probably be attributed the formation of the lakes of the Glatt valley, of the Greifen Lake and Pfaffikon Lake, in the same way as in the case of Rieg Lake and Staffel Lake, whilst Heim is disposed rather to explain the origin of these two lakes of the district of the Glatt valley to the blocking-up action of moraines.

There is, therefore, no real difference of opinion between us touching the Lake of Zurich and the Lakes of the Bavarian highlands, either as regards the facts or the conclusions from them; and as in the present case, so also does it often happen, that by a more exact conjoint examination, differences become of much less importance than they appear to be from a distance.

V.—Notes on some Rocks from Arabia Petræa.

By F. W. Rudler, F.G.S.,
of the Museum of Practical Geology.

PROFESSOR HULL, soon after his return from Palestine, was good enough to place in my hands, for microscopic examination, a collection of twenty sections of rocks prepared from specimens obtained in the course of his expedition. Subsequently I had the advantage of receiving thirteen small specimens of the rocks from which some of the sections had been cut; and respecting these rocks some lithological notes have been published as an appendix to Prof. Hull's Memoir.[1] At a later date I received seven other rock-specimens, representing the remaining sections in my charge; but for want of time these were laid aside unexamined until it was too late to refer to them in the published work. The object of the present notes is therefore to offer brief descriptions of these remaining rocks. At the same time I gladly seize this opportunity of correcting some errors which unfortunately crept into the previous descriptions.

I. *Pale Pink Granite, from a Dyke Penetrating Grey Granite, at Jebel Watiyeh.*

A fine-grained granitic rock, consisting mainly of opaque white felspar and hyaline grey quartz, speckled with a few dark green patches of an altered mica. It presents a general pinkish grey colour, due to a small quantity of ferric oxide disseminated through the rock, and specially marked on the weathered joint-surfaces of the specimen. The felspar is for the most part very turbid, even in thin sections. Many of the crystals exhibit a zonal structure, which is well defined by the arrangement of the included granular matter. Some of the felspar appears to be orthoclase, in an altered condition, and probably microcline is also present; but most of the felspar is a plagioclase, with extinction angles, in relation to the line of twin-composition, varying from 3° to 14°. In a good deal of the felspar, however, the edges of the hemitropic lamellæ are too blurred to allow the exact angles to be taken. Some of the felspar crystals measure in section as much as 3 mm. × 1·5 mm. The quartz is xenomorphous, occurring in the form of clear subangular grains, ranging from 0·5 to 1 mm. in diameter, and traversed by reticulating lines of pores. Much of it shows a polysynthetic structure in polarized light. A few folia of muscovite, or other white mica with straight extinctions, are distributed through the rock. This mineral may be a secondary product. But the dominant micaceous mineral is a biotite, or dark dichroic mica, occurring in aggregated laminæ, and mostly altered, after the habit of the ferro-magnesian micas, to a chloritic mineral. A few acicular crystals of apatite are present, penetrating alike the felspar and the quartz. Some grains of epidote may be detected; and magnetite is present in small quantity, while scattered through the rock are small patches of hematite and limonite, with here and there a few folia of chlorite.

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[1] "Memoir on the Physical Geology and Geography of Arabia Petræa, Palestine, and adjoining Districts," Palestine Exploration Committee (1886).

II. *Red Granitoid Rock, with Micropegmatitic Structure, from Jebel Watiyeh.*

This rock is an intimate aggregate of flesh-red felspar and quartz, with grains of vitreous quartz and crystals of felspar scattered through the ground-mass. It may be regarded as a fine-grained binary granite, almost a microgranite, with porphyritic quartz and felspar; thus suggesting a transition to a coarse kind of quartz-felsite with a ground-mass of phanero-crystalline texture. The felspar is highly charged with reddish-brown granules, perhaps kaolin with limonite, which by their comparative opacity render the section very nebulous. The felspar is presumably a red orthoclase, and is associated with large crystalline grains of clear quartz with numerous pores. In places the felspar and quartz of the ground-mass are so intimately united as to form a beautiful micropegmatite or granophyre. The association naturally suggests contemporaneous, and probably rapid, solidification of the two minerals. In some cases the formation of the micropegmatite has started from a pre-existing crystal of felspar, whence the interblended felspar and quartz diverge in plumose forms. This is the rock referred to by Prof. A. Geikie in his "Text-book of Geology," second edition, 1885, p. 635, footnote 3.

The rock from Jebel Musa, No. 1, in the Appendix to the Memoir, described as a gneiss, seems rather to be a fine-grained granitoid rock. The faint tendency to foliation, suggested by a small specimen, is illusory. The rock, though diverging greatly from the normal granitic type, and presenting rather a granulitic texture, may probably be best described as a hornblende-granite.

III. *Red Porphyrite from Jebel Musa.*

This rock presents a compact base of deep tile-red colour, with subconchoidal fracture, in which are disseminated porphyritic crystals of red felspar and irregular dark green patches of an altered mineral, apparently a mica. Some of the large felspars reach a size of 4 mm. × 1·5 mm. Even in thin section they present a strong reddish colour, which is deepest around the inner border of each crystal, where the granules of ferric oxide are accumulated. Some of the crystals seem to be orthoclase, but others show indistinct polysynthetic twinning, with broad lamellation. Zonal structure is presented by some of the crystals. The other porphyritic constituents are green crystals, measuring about 1·25 mm. × 1 mm. These seem to be pseudomorphs after biotite; at least such an origin is suggested by their strongly-marked striæ, which seem to represent the basal cleavage of a mica, by the occasional curvature of the laminæ, and by the hexagonal form of some of the sections. This green epigenetic mineral is strongly dichroic, and is flecked with an opaque oxide of iron, probably magnetite. The slide also carries some irregular patches of chlorite. Apatite is present in rather stout six-sided prisms, both in the felspars and in the altered mica. Epidote occurs in aggregates of greenish-yellow grains, inclosed in both the porphyritic minerals. Quartz may be detected in interstitial spaces, but is apparently of secondary origin. Probably the history of the rock has been somewhat of the following character:—The apatite, the biotite, the large felspars and the ground-mass successively solidified in the order here enumerated; the mica was afterwards transformed into a chloritic mineral, with separation of magnetite, while further alteration of the chlorite resulted in the formation of epidote, which may also have partly resulted from the decomposition of the felspar, inasmuch as it occurs in the heart of some of the larger felspar crystals.

IV. *Felsitic Tuff from Es Shomrah.*

This rock appears macroscopically to be a porphyritic felsite, with compact chocolate-coloured base and disseminated crystals of white felspar. Under the microscope, however, it is seen to contain angular fragments of various rocks, with broken crystals of plagioclase, forming a brecciated mass. Mr. F. Rutley, F.G.S., to whom I am indebted for having examined some of my sections, points out the general similarity of the ground-mass to that of the rhyolitic rock from Pont-y-Gromlech, which he described some years ago; but at the same time inclines to the view that in the present case the ground-mass consists of fine dust, in great part felspathic, perhaps associated with shreds of devitrified lava. Among the imbedded fragments, which vary in diameter from about 0·03 mm. to 2 mm., are rhyolites, or devitrified rocks showing banded and fluxion structure. Some of the fragments and imperfect crystals of felspar reach a size of 2·25 × 1·3 mm., and though mealy in texture, show traces of repeated twinning.

V. *Hornblende-augite Rock from Es Safeh.*

A coarsely crystalline, almost black rock, weathering with a rusty surface. Thin sections show large porphyritic crystals of brownish-green hornblende, colourless augite, and decomposed felspar, imbedded in a pale brownish ground-mass of felspathic microlites, with green products of decomposition. Some of the crystals of hornblende measure, in section, as much as 3 mm. × 1·2 mm. Most of them are much fissured and carious, inclosing green alteration-products, and having rather indistinct outlines, bordered by dark greenish granules. The best-defined sections are those cut approximately normal to the perpendicular axis. These show the common six-sided forms, bounded by the edges of $\{110\}$ $\{010\}$, with intersecting lines of prismatic cleavage breaking up the section into characteristic rhombs. Elongated sections parallel to the vertical axis give longitudinal cleavage lines, and the extinction-angles in relation to these lines vary from 0° in some of the sections which are cut parallel to $\{100\}$, to a maximum of about 15°. The pleochroism is not very marked: $\mathfrak{a}$ = pale yellowish brown, $\mathfrak{b}$ = pale bottle green, $\mathfrak{c}$ = olive green. Much of the hornblende is twinned.

The augite appears in very sharply-defined crystals, which in thin sections are quite clear and colourless. Most of the sections are eight-sided, being limited by edges of $\{110\}$ $\{100\}$ $\{010\}$. Some of these measure nearly 1 mm. in the edge. The prismatic planes dominate in some of the sections, and the pinacoids in others. The characteristic cleavage parallel to {110} is well displayed. Some sections of rhombic shape, cut approximately in the plane of symmetry (010), give extinction angles of nearly 40°.

Two sets of felspars may be noted. Those of the first consolidation occur in groups of large crystals, some of which give sections reaching a size of 2 mm. × 0·6 mm., three or four such crystals forming a cluster. All the felspar is profoundly altered. By reflected light it presents a dead white colour, but by transmitted light a reddish tint. Notwithstanding its advanced state of decomposition, the repeated twinning of a plagioclase may be detected, and the wide extinction angles of the broad lamellæ suggest a felspar of high basicity. The small felspars of later consolidation occur in crowds of slender interlacing crystals, with irregularly-terminated lath-shaped sections, measuring on an average 0·16 × 0·04 mm. The meshes of this reticulating mass of microlites are occupied by a green decomposition product, of fibrous and tufted structure, with strong depolarizing action between crossed Nicols. There are also large irregular patches of a green mineral, chloritic or serpentinous, following irregular cracks in the rock, and associated with calcite and epidote. The calcite also forms large crystalline masses and ill-defined patches, with aggregate polarization. Olivine appears to be represented by crystals which have suffered much alteration, and are mostly converted into green pseudomorphs with a brown margin. Magnetite is disseminated through the rock, and red and brown oxides of iron occur in patches.

It does not appear easy to bestow upon this rock an appropriate name. It is very similar to the rock No. 13, from Jebel esh Shomreh, described in the Appendix to the Memoir as a hornblende-augite andesite, but I am anxious to withdraw that name, as the rock is decidedly basic. Notwithstanding the large proportion of hornblende, the affinities of the rock appear to lie rather with the dolerites and diabases. Its structure is in no way related to that of the diorites. With a little more olivine and a little less felspar it might perhaps claim a place among the hornblende-picrites, which have been so well described by Professor Bonney, D.Sc., F.R.S.

VI. *Dolerite from Gehat es Shomrah.*

A dark-brown, nearly black, rather fine-grained rock, with large porphyritic crystals of greyish felspar with greasy lustre. The ground-mass, viewed in the microscope, consists mainly of a confused network of felspars, yielding lath-shaped sections, mostly binary twins, with an average size of 0·03 mm. × 0·007 mm. The augite occurs in crystalline grains and small crystalline masses, of brown colour, occupying the spaces between the felspars, and evidently of later consolidation. Indeed, the penetration of the augite by the felspar gives rise to an indistinct ophitic structure. Olivine is present, partly serpentinized, in the form of amber-coloured grains, with here and there a small crystal. One well-marked crystal, of irregular six-sided shape, measured 0·8 × 0·3 mm.; like the other olivines in the section it contains magnetite along its cleavage cracks and curved fissures. Magnetite is freely disseminated throughout the rock. With a high power crowds of colourless acicular microlites, perhaps apatite, come into view. A little calcite, showing aggregate polarization, is present as a secondary product. No distinct interstitial matter can be detected, and indeed the rock appears to be a holocrystalline dolerite. A porphyritic structure is imparted to the rock by large crystals of felspar, the rectangular sections of which may measure as much as 8 mm. × 2 mm. This felspar shows sharply-defined twin lamellation, and in some sections there are two sets of lamellæ approximately at right angles to each other, thus suggesting that the plagioclase is twinned on both the pericline and albite types. From its high extinction-angles, reaching 40°, it is probably a basic felspar near to anorthite.

VII. *Dolerite from Wady es Shiek.*

A medium-grained, dark-brown rock, much altered, and weathering with a yellow rusty surface. It presents in thin section a dense network of plagioclase in rather thick rectangular sections, with an average size of 1 × 0·25 mm. They inclose dark greenish-brown granular matter, so disposed in some cases as to give a zonal appearance to the sections. Augite occurs in crystalline grains and granular aggregates. The space between the felspars is largely occupied by serpentinous matter, and much of the substance which at first sight looks like interstitial matter is probably a product of alteration. Magnetite is abundant, and scales of red oxide of iron are scattered through the rock. Crowds of minute acicular microlites become visible with a high power.

A re-examination of the diabase, No. 12 in the Appendix, shows that all the quartz is of secondary origin, and hence the rock is simply a diabase with quartz, and not a quartz-diabase. With reference to the felsite, No. 10, it should have been stated that the description applied only to the particular thin section under examination.

I am greatly indebted to Mr. J. J. H. Teall, M.A., F.G.S., and to Mr. T. Davies, F.G.S., for having examined with me some of the sections described in these notes.

VI.—ON THE MICROZOA FOUND IN SOME JURASSIC ROCKS OF ENGLAND.

By Professor T. RUPERT JONES, F.R.S., AND C. D. SHERBORN, Esq.

IN the GEOLOGICAL MAGAZINE, Dec. II. Vol. II. 1875, p. 308, is a list of some English Jurassic Foraminifera, a large number of species being there noted as occurring in these rocks. We have lately received, by the friendly courtesy of the Rev. H. H. Winwood, F.G.S., and Horace B. Woodward, Esq., F.G.S., thirteen specimens of the Jurassic rocks from the south-west of England. One of these has yielded a most important series of Ostracoda. Whilst preparing a special monograph, we hasten to offer some preliminary notes on these interesting Jurassic Microzoa, at present merely noting the genera, in descending order of strata, and deferring the specific nomenclature for a subsequent opportunity.

1. "Kimmeridge Clay, near Coulston, Wilts." H. B. W.

A mottled (blue and yellow-brown) clay, very stiff and greasy to the touch. Residuum, after washing, a very little, fine, subangular sand, with minute woody fibres. Microzoa rare and very small, of a brown colour and with a sandy appearance. The *Foraminifera* are *Trochammina incerta; T.*, sp. near *oligogyra*, Hantken; and another near *gordialis; Marginulina = Cristellaria Zitteli*, Schwager; *Cristellaria* sp.; *Nonionina*, sp.; *Orbulina neojurensis*, Karrer; and a three-chambered *Globigerina*. These minute fossils are beautifully preserved. No Ostracoda were found.

2. "Clay at the base of the Lower Greensand and on the top of the Corallian; Seend, Wilts. Most likely Kimmeridge Clay." H.B.W.

A pale-grey clay (when dry).

This specimen was washed completely away, leaving neither Microzoa nor sand.

3. "Clay above Iron-ore deposit; Westbury Ironworks, S. of Station. ? Kimmeridge Clay." Rev. H. H. W.

A stiff, mottled, blue clay, with numerous very small, rounded, shining, black concretions.

This left a very small, but rich, residuum of Foraminifera, having a very characteristic Jurassic facies. Amongst the forms are *Lingulina carinata*, var. (this is an oval *Nodosarina*, and, although the mouth appears to be a *circle* of radiating fissures, we think it should be regarded as more Linguline than Nodosarine in character); *Nodosaria*, sp. near *nitidula* (Gümbel, 'Streitberger Schwammlager'); *Dentalina communis; Planularia reticulata; P. pauperata*, narrow, broad, and thin varieties; *Vaginulina cristellarioides; V. orthonota; V. angustissima; V. harpa*, and two others (the first four are figured by Reuss in his 'Norddeutschen Hils und Gault'); *Cristellaria rotulata* with three varieties leading into the next "species," *Cristellaria crepidula*; and *Haplophragmium Canariense.*

These forms are well preserved. No Ostracoda were found.

4. "Yellow Fullers-earth Clay; Midford." Rev. H. H. W. and H. B. W.

This and the following clay are described by Horace B. Woodward in his "Geology of England and Wales" (p. 182) as "a sandy clay, which is described by Mr. Bristow as usually of a greenish-brown or greenish-grey colour, sometimes blue. It is opaque, soft, dull, with a greasy feel, and an earthy fracture." The specimens sent were of a yellow-brown colour.

From the specimen of yellow clay we obtained only two species of Foraminifera, *Cristellaria crepidula* and *Vaginulina legumen*, var.

It is richer, however, in Entomostraca, five species of *Cythere*; two of *Cytherideis*; three of *Cytherella*; and one of *Bairdia*, rewarding our search.

5. "Blue Fullers-Earth; Midford." Rev. H. H. W. and H. B. W.

An indigo-blue clay, drying bluish-grey, extremely rich in Microzoa, especially Ostracoda. It is rather singular that this most remarkable deposit of Entomostraca has not been noticed before. We have mounted and arranged upwards of three hundred individuals of more than fifty species already, and look for a much larger number before we close our work. The majority of the species were obtained from little more than one pound weight of material. Foraminifera are much scarcer, but there is the same proportionate abundance between the two groups as in the yellow-brown clay above described. A few fragments of shells also occurred, but too imperfect for identification; also ossicles of Pentacrinus, and a few broken minute spines of Echinoderms.

The Foraminifera include a subcarinate variety of *Cristellaria rotulata*, near to one figured by Jones and Parker (Q.J.G.S. vol. xvi. 1860, pl. xx. f. 43); *Cristellaria crepidula*; *Vaginulina legumen*; *Planularia*, sp. near *reticulata*, Cornuel; *Nodosaria lineolata*, Reuss, and *Frondicularia peregrina*, Reuss ('Bohm. Kreide'); and a simple four-rayed star, like the "Siderolina-like forms" figured by Gümbel from the "Streitberger Schwammlager" in "Jahresh. Ver. nat. Württ. 1862, Jahrg. 18, p. 235, pl. iv. f. 19. This little specimen has been shown to Dr. Hinde, who thinks that, although calcareous, it is most likely a modified dermal spicule of a hexactinellid Sponge.

The Entomostraca represent, provisionally, thirty-four species of *Cythere*; three of *Cytherideis*; three of *Cytheridea*; five of *Cytherella*; six of *Bairdia*, also *Cytherura*, *Pontocypris*, *Macrocypris*, and possibly *Aglaia* and *Argillœcia*.

The examination of these forms is affording us very great pleasure, being, though exceedingly small, very finely preserved and perfect. It is interesting to note, that we identify some ten of them as occurring amongst those figured from the Richmond Well in Q.J.G.S. vol. xl. pl. xxxiv.

6. "Loamy beds in Hinton Sand, Forest-marble; Charterhouse-Hinton, Somerset." H.B.W.

A light-brown loam with small "clay galls." This leaves after washing a residuum of fine, subangular, quartzose sand. After careful search we found some extremely small Foraminifera and one Ostracod:—*Cristellaria crepidula*; *Marginulina glabra*; and a valve of *Cythere*.

7. "Bradford Clay; Bradford. This is the clean clay immediately overlying the fossil-bed." H.B.W.

A light-brown clay, which, on washing, left a few waterworn Entomostraca and two *much* waterworn Foraminifera. The latter are *Cristellaria crepidula* and *Vaginulina legumen*; and the former are three varieties of *Cythere*.

8. "Bradford, No. 1. Near Canal. *Locus classicus.*" Rev. H.H.W. No Microzoa found on examination.

9. Bradford, No. 2. Near Bradford. Little higher in position than No. 1." Rev. H.H.W. No Microzoa.

10. "Oxfordian; Upper Studley, Trowbridge. Probably Kellaways Rock." H.B.W.

Dark greenish-brown, friable sandstone of subangular quartzose sand, with calcareous cement. No Microzoa found.

11. "Oxford Clay; Bromham Brickyard. South of Sandridge Hills, between Melksham and Devizes." H.B.W.

A few fragments of shells, but no Microzoa, were found.

12. "Oxford Clay; Upper Studley, Trowbridge." H.B.W.

Very pale, yellowish-grey, sandy clay, yielding after washing, about 50 per cent. of extremely fine, white, subangular, quartzose sand. No Microzoa.

13. "Oxford Clay; Southwick, Trowbridge." H.B.W.

Like No. 12, leaving, after washing, the same remarkably fine, white sand, and presenting no trace of Microzoa.

NOTE.—Beside the Jurassic specimens we have one from the Cretaceous series of the same district, namely:—"Clay seam in Lower Greensand; Seend." H.B.W.

A ferruginous sandy clay; bound together in places by the iron and forming "pan."

By washing, this specimen yielded abundance of subangular sand, with a little mica.

No Microzoa were met with.

NOTICES OF MEMOIRS.

I.—M. DOLLO ON THE EVOLUTION OF THE TEETH OF HERBIVOROUS DINOSAURIA.

ALL palæontologists who are interested in the marvellous reptilian life of the Secondary epoch owe a debt of gratitude to M. Dollo of the Royal Museum of Brussels for the ability and care with which he has elucidated the structure and affinity of the unrivalled collection of Dinosaurian and other reptilian remains preserved in that Museum. One of the most interesting of his

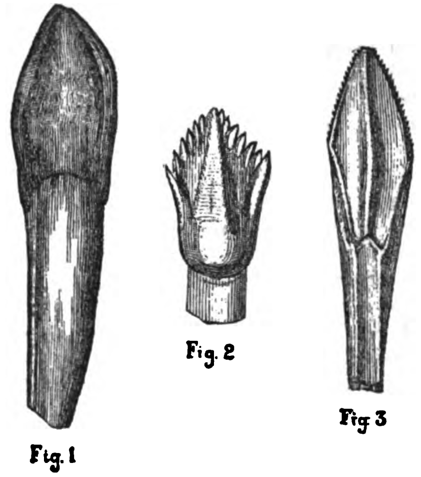

DIAGRAM A.—FIG. 1. Tooth of *Morosaurus*. FIG. 2. of *Scelidosaurus*. FIG. 3. of *Hadrosaurus*.

contributions[1] to our knowledge of the Dinosauria shows how the teeth of the herbivorous members of that order have gradually increased in complexity of structure, and as the author has kindly allowed the use of some of the woodcuts illustrating his memoir, we have great pleasure in laying before our readers a sketch of this line of evolution.

In the generalized suborder Sauropoda, which is mainly Jurassic and died out after the Wealden, we find that the teeth, as in *Morosaurus* (Diagram A, Fig. 1), are perfectly simple, having neither serrated edges, nor carrying ridges on their lateral surfaces. In the generalized Jurassic Stegosauria the teeth still retain the same simple structure, but in the more specialised members of this suborder (e.g. *Scelidosaurus*, Diagram A, Fig. 2), which occur in both the Jurassic and Cretaceous, they have developed serrations on the edges, although not distinct lateral ridges. The next step is presented by certain members of the Ornithopoda, as *Hadrosaurus* (Diagram A, Fig. 3), where a distinct vertical ridge is developed in addition to the serrated edges. Advancing to the more specialised Ornithopoda-like *Iguanodon* (Diagram B), we find that secondary lateral ridges are developed; and we may further observe that while in the Jurassic *I. Prestwichi* both primary and secondary ridges are simple, in the Wealden *I. Mantelli* the former has become serrated. The last step

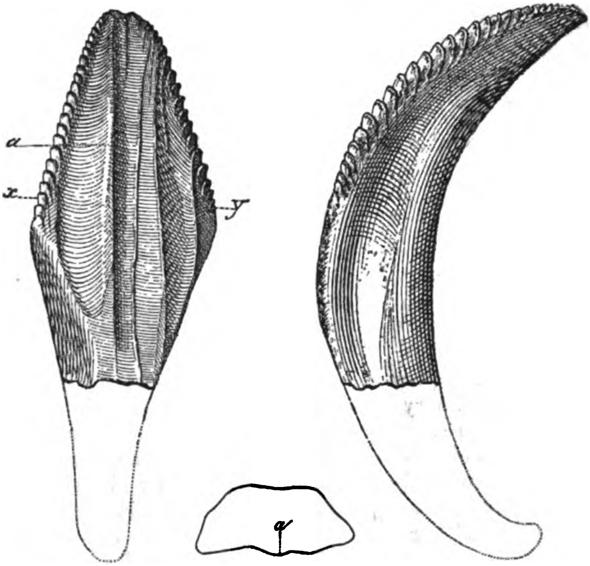

Fig. 1 Fig. 3 Fig. 2

DIAGRAM B.—FIG. 1. Tooth of *Iguanodon Prestwichi*; from the enamelled surface. FIG. 2 in profile. FIG. 3 section from *x* to *y*, $\frac{1}{1}$. *a* shows the principal lateral ridge without serrations.

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[1] Ann. Soc. Sci. Bruxelles, 1885, pp. 309-338.

but one is afforded by the remarkable teeth from the Upper Cretaceous (Senonien) described by M. Dollo under the name of *Craspedodon lonzeensis* (Diagram C), in which, in addition to antero-posterior serrations, there are primary, secondary, and tertiary lateral ridges, of which both primary and secondary are serrated. Finally the American *Cionodon* simulates the dentition of Ungulate Mammals in having numerous cheek-teeth in use at one and the same time.

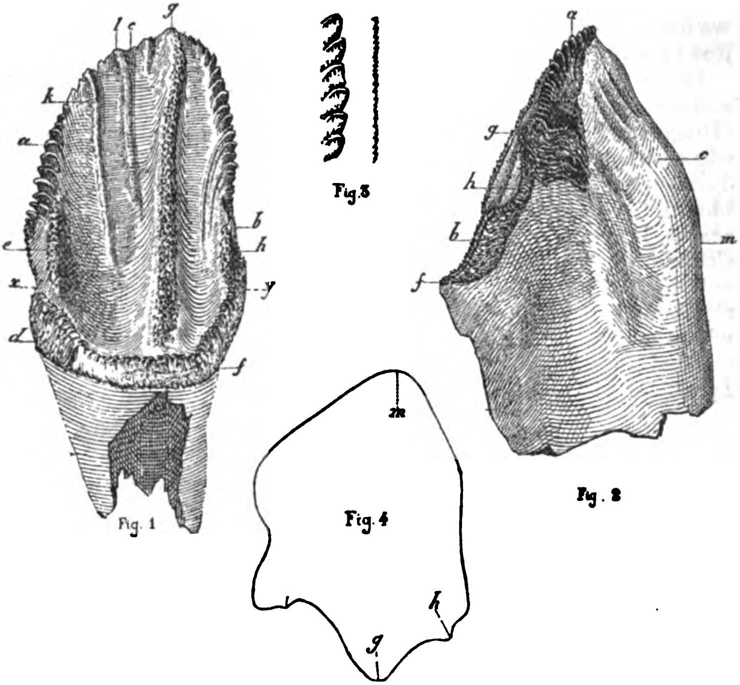

Diagram C.—Tooth of *Craspedodon lonzeensis*. Fig. 1 from the enamelled surface, $\frac{2}{1}$; *c* crown, *d f* cingulum, the letters *a b e g h k l* indicate the serrations and ridges. Fig. 2 in profile, $\frac{2}{1}$. Fig. 3 the large and small serrations more magnified. Fig. 4 section at *x y*, $\frac{2}{1}$.

M. Dollo concludes this interesting survey by observing that "it appears that while the specialization of the dentition in the Ungulata has taken place either by the development of infoldings in the enamel (*Equidæ*), or by the multiplication of tubercles (*Suidæ*), accompanied by gradual elevation of the crown, it has manifested itself in the herbivorous Dinosauria by the development of ridges and serrations, or by the simultaneous use of numerous teeth. While, however, the cause of the evolution of the dentition of the Ungulata is, so to speak, known to us, we can only guess at that of the dentary system of the great Reptiles which filled their place during the Secondary epoch." R. Lydekker.

II.—EMMONS' ORIGINAL TACONIC SERIES.

1. ON LOWER SILURIAN FOSSILS FROM A LIMESTONE OF THE ORIGINAL TACONIC OF EMMONS. By J. D. DANA.

2. PRELIMINARY REPORT OF S. W. FORD AND W. B. DWIGHT UPON FOSSILS OBTAINED IN 1885 FROM METAMORPHIC LIMESTONES OF THE TACONIC SERIES OF EMMONS, AT CANAAN, NEW YORK. American Journal of Science, vol. xxxi. p. 241—253, pl. vii. April, 1886.

PROFESSOR DANA points out that the *original* and therefore *true* Taconic system of Prof. Emmons, which this geologist propounded and described in 1842, "lies along both sides of the Taconic range of mountains, whose direction is nearly north and south, or, for a great distance, parallel with the boundary-line between the State of New York and those of Connecticut, Massachusetts, and Vermont." Emmons described it as consisting of (1) "Taconic slates" in eastern New York, including the Hoosic slates; (2) the Sparry or western limestone, interstratified with the slates, west of the Taconic range, and for the most part lying against the west side of the range; (3) the "talcose" or "magnesian" schist, constituting the Taconic range, and Greylock or Saddle Mountain, the high ridge between Williamstown and Adams in the north-western angle of Massachusetts; (4) the Stockbridge Limestone, east of the range of Taconic schist; (5) Quartzite. Prof. Emmons concluded, on lithological grounds, that the system was older than the New York Potsdam Sandstone, and equivalent to the Lower Cambrian of Sedgwick. Subsequently, in Washington County, New York, outside the typical area of the Taconic system, Emmons discovered, in black slates, some Trilobites, pronounced by Barrande to be *Primordial* species. These black shales were regarded as more recent than the typical rocks, in which no fossils whatever had been discovered, and Emmons called them therefore Newer or Upper Taconic.

But now recently fossils have been discovered in the Sparry or Western Limestone, the oldest limestone of Emmons' original Taconic, and in a locality in the typical area of the system. The fossils are very fragmentary, and can only be examined by means of thin sections and polished surfaces of the rock. They show, however, the presence of distinct species of *Murchisonia, Pleurotomaria,* and *Fenestella*, as well as portions of Crinoids, probably of Brachiopods, and of a Trilobite. Prof. Dwight and Mr. Ford, who have studied the fossils, believe that they indicate the Trenton age of the limestone in which they are preserved.

It follows from this discovery that the age of the typical Taconic system of Emmons is not Cambrian or Pre-Cambrian, as stated by him, and that the black shales and limestones with Primordial Trilobites, forming his Newer or Upper Taconic system, really belong to a period much older than the so-called Lower Taconic. G. J. H.

REVIEWS.

Geological Survey of S. Australia.

Report on the Geological Character of Barossa and Para Wirra, South Australia.

Notes, etc., Explanatory of Parliamentary Paper No. 178, with a Geological Map of Pira Wirra and Barossa Reserves. By Henry Y. Lyell Brown, F.G.S., Government Geologist, assisted by Harry Page Woodward, F.G.S. Folio. (Adelaide, 1886.)

The Barossa and Para Wirra Goldfields.

The Barossa goldfield is situated in the south-west corner of the hundred of that name; it is separated from the Humbug Scrub goldfields only by the South Para River, which latter is also included in the map. It was discovered in October, 1868, by Job Harris and mates, who found gold in the gully now known as Spike gully. This gully is about one mile and a half long—the prospector's claim being near the middle.

The depth of sinking was from 5 ft. to 20 ft., and some of the claims were very rich, yielding as much as £1000 per man.

The general features are a main rocky range, running from north to south, of which Mount Gawler, near the south end, attains a height above the sea of 1789 ft. This range is flanked on either side by patches of Tertiary deposits, on the spurs between which the gullies descend gently into Malcolm's Creek on the east, and through steep rocky gorges into the Little Para, Gould's and Tenafeate Creeks on the west. The north end of the reserve, in Barossa, is divided from that in Para Wirra by the deep rough gorge of the South Para River. Here the main ridge runs north-west and south-east, following the course of the river, and being capped on its highest part by Tertiary beds, with its small steep gullies running south into the Para River, and north down a gentle incline into the Yetti Creek.

The rocks of this district are supposed to be of Lower Silurian age, from their lithological resemblance to those of the Victorian goldfields, although from their highly metamorphic appearance, and no fossils having been found, it is impossible to say decidedly of what age they are. In several places intrusive granite dykes are met with, and in one particular line, from Malcolm's Creek to Mount Gawler, they are very frequent.

These rocks consist of metamorphic argillaceous and micaceous schists, slates, sandstones and grits, granite, gneiss, hornblende schists, mica schist and quartzites with granite, greenstone, and felspathic dykes. As a rule they have a uniform strike of about 20° east of north, and dip to the eastward from 35° to 70°; the only exception to this rule seems to be near the Bismarck diggings, where the dip is 70° west in two places; but this is probably caused by local agency, as it does not extend far.

Nearly all the rocks of this district, especially on the ridges, have so highly weathered an appearance, and are so decomposed, that they might often be taken for Tertiary cements, particularly some coarse-grained metamorphic granites, which contain a great deal of iron. The only place where the rocks are not highly altered is along the Yetti Creek, where they consist of sandstones and slates.

Pliocene Leads, Deep Leads, or made ground.—During the Tertiary period, the main range was already elevated considerably and two main streams flowed, one on each flank, into which small gullies probably ran. Both these creeks flowed north, as is proved by the level of their old beds descending in that direction. The one on the east side seems to have risen somewhere near Mount Gawler, thence flowing in a northerly direction, its course being now traced by a few out-lying patches of made ground, and by a general line of low country crossing the present creeks.

The other had its rise somewhere to the southward, and passed on the west side of Mount Gawler, and flowed northward towards the Humbug Scrub, where, at the head of Leg of Mutton Gully, it was joined by the eastern stream. Thus increased in size, it flowed across the present river to the Barossa goldfield, and so on in a north-westerly direction to Gawler, where it discharged itself into the sea. This is deduced from the position of outlying patches of Tertiary gravel, sand, and clay (marked yellow on the map), which have escaped denudation.

These deposits constitute the old gold drifts from which a considerable amount of gold has been obtained in Barossa, and a small amount in Para Wirra. As the payable portion of these gold drifts can only be ascertained by sinking shafts—often through hard conglomerate, the gold occurring in gutters beneath—a considerable amount of labour has to be performed before a run of gold is struck; in consequence, a large area consisting of patches of this Pliocene Tertiary has not yet been prospected by the gold miner. Here and there a hole has been put down, but only in a random manner; and the ground still remains unproved.

The patches of old gold drift, which are known as "made hills," are generally characterized by ferruginous sandstone and conglomerate capping, called cement, which being very hard, has protected the softer beds of sand, pipeclay, and gravel, from being washed away.

In some cases the lower beds have been cemented, in which case crushing mills had to be employed to obtain the gold.

Para Wirra Gold Reefs.—General Notes.

The Lady Alice reef has only been worked to a depth of about 160 ft., and is well worth being farther prospected below that level, considering the richness of the stone already raised and the shallow depth from which it was obtained.

The various reefs and veins which are at the present time being prospected on the Young Australian property show good prospects of gold on and near the surface. They are worthy of a more systematic and extensive examination by means of shafts.

An examination of the map will show what a comparatively small area of that occupied by Tertiary deposits of older gold-drift has been prospected for gold. Shafts have been sunk here and there. Some of these have not been bottomed, *i.e.* have not reached the bed-rock; others have bottomed on high ground, and the run of gold has not been immediately struck, consequently operations have been suspended forthwith. Some of the gullies between the patches of older gold-drift should be prospected for gold washed out of the "lead" across the course of which they have been eroded. Where these gullies are deeply cut into the bed-rock, an opportunity is afforded of testing the junction between the bed-rock and the Tertiary drift by drives or tunnels. In other places, where the country is flat, trial shafts will be necessary to prove the auriferous nature of these deposits.

The bed of the South Para River should contain payable alluvial gold, as a large area of Tertiary gold-drift, which at one time was continuous, from Para Wirra into Barossa, has been denuded by the river, and the gold it contained sluiced down and re-deposited in its valley.

Mr. Selwyn, in his "Geological Notes of a Journey in South Australia from Cape Jarvis to Mount Serle," in 1859, recommended the testing of parcels of quartz from the reefs, and a search for gold in the Tertiary gravels of the Mount Crawford district, ten years before gold was found.

The information referring to the history of the diggings, depth of shafts, etc., has been obtained from Messrs. Goddard, Barkla, Dawes, Turner, Trenowden, Smith, and Bayley, residents of the district. That relating to the yield of gold and copper from the Lady Alice mine has been supplied by Mr. W. R. Lewis, who was secretary to the company from 1873 to 1879, and Mr. G. C. Faid.

The Report contains a summary of the results of all the gold workings in both the Barossa Gold-reefs and those of Para Wirra, and is accompanied by an excellent map, prepared by H. P. Woodward, F.G.S., Assistant Government Geologist. The Report is dated December 10th, 1885.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—April 21, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On a certain Fossiliferous Pebble-band in the 'Olive group' of the Eastern Salt Range, Punjab." By A. B. Wynne, Esq., F.G.S.

The principal object of this paper was to oppose the views recently published by Dr. Waagen as to the age of certain boulder-beds in the Salt Range of the Punjab. By that author these beds had been considered contemporaneous with each other, and assigned to the epoch of the Coal-measures, in consequence of the discovery by Dr. Warth of Carboniferous fossils, especially Australian forms of *Conularia,* in nodules restricted to a particular layer in the upper part of a boulder-bed in the eastern Salt Range. Mr. Wynne adduced evidence to show that the fossils in question occur, not in concretions, as supposed by Dr. Waagen, but in pebbles evidently derived from an older series; and consequently there was no proof that the boulder-bed in question was older than the Cretaceous Olive beds with which it had hitherto been associated.

The principal boulder-beds in the Salt Range were then briefly noticed; those beneath the Carboniferous Limestone west of the Indus, those near Amb and Sakesir peak, associated with the "purple sandstone," "*Obolus*-beds," and "speckled sandstone," and those in the eastern portion of the Salt Range, amongst the beds of the "Salt pseudomorph zone" and "Olive group," being successively passed in review, and their relations to overlying and underlying strata explained. It was shown that boulder-beds and conglomerates containing pebbles and boulders of the same crystalline rocks are not confined to one horizon.

In conclusion, the resemblance of the rock, of which the pebbles containing *Conulariæ*, etc., were formed, to that forming some of the "magnesian sandstone" and "*Obolus*-beds," was pointed out, and it was suggested that the pebbles in question may have been derived from representatives of those beds formerly existing to the southward.

2. "On the Phosphatic Beds in the Neighbourhood of Mons." By M. F. L. Cornet, For. Corr. G. S.

The beds are situate in the province of Hainaut, near the town of Mons (Belgium); the workings have increased of late years, and in 1884 yielded 85,000 tons of phosphate.

They occur in the Upper Cretaceous, which is exceptionally well developed in the district, filling a trough in the Carboniferous rocks, and itself denuded for the reception of Tertiary and Quaternary beds.

Omitting all Cretaceous groups below the middle of the fifth stage, the following is the sequence of the Cretaceous beds which contain the phosphatic series:—

C. Tufaceous Chalk of Ciply, with the Poudingue de la Malogne at its base.
D. *Brown Phosphatic Chalk of Ciply.*
E. Coarse chalk of Spiennes.
F. White chalk of Nouvelles.

F is a pure white chalk with some flints and contains *Belemnitella mucronata*, *Rhynchonella octoplicata*, *Terebrutula carnea*, *Ananchytes ovatus*, etc.—an horizon well known throughout North-western Europe. Series E and D represent one geological horizon, characterized by *Ostrææ*, Brachiopoda, etc., in great numbers, but also containing *Belemnitella mucronata*, and lying between two distinct planes of erosion.

The Brown Phosphatic Chalk (D), which forms the Upper division of the series, is about 70 feet thick, and may be described as consisting of three parts; the upper is tolerably pure carbonate of lime, but in its lower portion becomes charged with brown granules mainly consisting of phosphate of lime; these continue to increase towards the central or main phosphatic mass, which is also highly fossiliferous in places. This central portion constitutes the main phosphatic beds, but the amount of phosphoric acid (dry) is not more than 12 per cent.

Hence, it is necessary to increase the richness in phosphate of the deposit in order that it may be available for conversion into a superphosphate. This may be done by mechanical means.

But nature has already partially anticipated this process, and the result has been a deposit known as "rich phosphate," containing about 25 per cent. of phosphoric acid. This occurs in wide cracks and holes in the ordinary phosphatic chalk. It usually occurs as a fine sand-like powder, and is evidently the result of the action of carbonated waters upon the phosphatic chalk, whereby the amount of carbonate of lime is reduced. This is especially the case where the phosphatic chalk is not protected by the tufaceous chalk of Ciply, but is only covered by Tertiary or Quaternary beds.

The author calculates that each square foot of the phosphatic basin, which he estimates approximately at five miles by three, contains 355lbs. of tribasic phosphate of lime. Finally he estimates how the phosphatization of the chalk may have been brought about.

II.—May 12, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Maxilla of *Iguanodon.*" By J. W. Hulke, Esq., F.R.S., F.G.S.

Two fragments, together representing nearly the entire left maxilla of a species of *Iguanodon*, have been found at Cuckfield, the locality whence the first tooth of the genus was obtained by Dr. Mantell, about 1820. These fragments, measuring together 29 centimetres, and exhibiting 19 alveoli in the dentary border, were described in the paper. It was shown that the upper jaw in question probably belonged to *Iguanodon Mantelli.* In addition to the detailed characters described, the maxillæ of *Iguanodon* and *Hypsilophodon* were compared, and their distinctions explained.

2. "Notes on the Distribution of the Ostracoda of the Carboniferous Formations of the British Isles." By Prof. T. Rupert Jones, F.R.S., F.G.S., and J. W. Kirkby, Esq.

Although all the Ostracoda of the Carboniferous formations are not yet described, there are 170 species and notable varieties known, belonging to 33 genera of 9 families. About 25 of these species, not yet described, but determined by the authors, are introduced into their lists as giving a fuller idea of the value of this manifold Crustacean group.

In the first place they referred to the classification of the Carboniferous strata in Scotland and in England, according to the local differences, taking in succession "Scotland West," "Scotland East," "England North, with the Isle of Man," "England Central and South, with South Wales," as the several districts from which they have obtained good groups of Ostracoda from different members of the Carboniferous series.

In Fife, the lowest local Carboniferous strata contain *Beyrichia subarcuata;* higher up come in *Carbonia fabulina*, *C. Rankiniana*, *Bairdia nitida* and *Leperditia Okeni;* the last, accompanied by other species, occurs throughout this lowest series, in which the record is more complete than in Midlothian and Linlithgowshire, where the same species also occur. In Dumfriesshire and Ayrshire *Leperditia Okeni* and *L. subrecta* have been found in beds even lower than the above mentioned, and are therefore probably the oldest Carboniferous Ostracoda; other species accompany them higher up, and in Roxburghshire some localities of the Carboniferous-sandstone series are very rich in species. The Carboniferous-Limestone series of S.W. Scotland has been highly productive of Ostracoda, particularly the shales of the lower beds; 36 species are common or characteristic. The middle or coal-bearing portion has yielded but few, chiefly *Leperditia Youngiana*, one *Beyrichia*, *Carbonia fabulina*, and *C. Rankiniana*. The Upper-Limestone group contains many recurrents from below and a few others, including *Youngia rectidorsalis* (MS.). The Millstone-Grit equivalents have no Ostracoda; but the overlying Coal-measures are rich in *Carboniæ*, with a few others, such as *Cypridina radiata*.

A great variety of genera and species come from beds at or near the base of the Scar Limestone and its equivalents in North Lancashire, Westmoreland, Cumberland, and Northumberland. The Calcareous shales of the Yoredale have several interesting forms, including *Phreatura concinna* (MS.); none from the Millstone-Grit.

The Lower Coal-measures give *Beyrichia arcuata* and *Carbonia*, sp. The middle beds have *B. arcuata* and *Carbonia fabulina*, common; rarer, *C. Rankiniana*, *C. secans*, *C. scalpellus*, *C. Wardiana* (MS.), and *Philomedes elongata*. In the Upper Coal-measures *B. subarcuata* reappears; and in the *Spirorbis*-limestone *Leperditia inflata* is the latest Carboniferous Ostracod in England.

In Northamptonshire the deep Gayton boring (at 730 feet) has given *Kirkbya variabilis*, *K. plicata*, *Bythocypris sublunata*, *Macrocypris Jonesiana*, *Cytherella extuberata*, and *C. attenuata*, all but one belonging to the Lower-Carboniferous series. In Salop, South Wales, and Somerset the Carboniferous Limestone has yielded several good species of *Leperditia*, *Kirkbya*, *Moorea*, *Bythocypris*, *Bairdia*, etc. *Carbonia Agnes* and *C. Evelinæ* belong to the South-Welsh Coal-measures.

The distribution of the Carboniferous Ostracoda in Ireland requires further work; but the Lower-Carboniferous Shales and the Mountain Limestone near Cork and elsewhere are very rich, as are also some parts of the latter in the Isle of Man.

The Ostracoda of the Permian formation were then treated of in relation to their Carboniferous allies, and the range of the British Carboniferous Ostracods in Europe and North America was noticed in some detail.

The results of the examination were shown in two extensive tables.

3. "Note on some Vertebrata of the Red Crag." By R. Lydekker, Esq., F.G.S.

This communication contained briefly the results of a re-examination of the specimens from the bone-bed of the Red Crag in the British and Ipswich Museums, a series of casts from the latter having been added to the former. The forms noticed were *Hyæna striata*, with which *H. antiqua* and *H arvernensis* were considered probably identical; *Mastodon*, of which the author thought three species, *M. arvernensis*, *M. longirostris* and *M. Borsoni*, were represented; *Sus*, of which two forms, the larger probably *S. erymanthius* or *S. antiquus*, the smaller *S. palæochœrus*, had been detected; a Tapir, which was probably *Tapirus arvernensis* or *T. elegans* rather than *T. priscus*; *Hipparion gracile*; a *Rhinoceros* referable to the hornless *R. incisivus* rather than to *R. Schleiermacheri*, though the latter probably also occurred; a species of Albatross (*Diomedea*) represented by a right tarso-metatarsus, and the associated proximal phalangeal bone of the fourth digit.

4. "The Pleistocene Succession in the Trent Basin." By R. M. Deeley, Esq., F.G.S.

The author, after referring to the previous publications on the subject, proceeded to notice the leading characters of the greatly developed Pleistocene deposits in the area drained by the Trent river and its tributaries. He proposed to classify the beds in question under three divisions, comprising the following stages. The beds of the lowest division were distinguished from those of the middle and upper by the absence of Cretaceous rock-débris.

OLDER PLEISTOCENE.	Early Pennine Boulder-clay.
	Quartzose Sand.
	Middle Pennine Boulder-clay.
MIDDLE PLEISTOCENE.	Melton Sand.
	Great Chalky Boulder-clay.
	Chalky Sand and Gravel.
NEWER PLEISTOCENE.	Interglacial River-alluvium.
	Later Pennine Boulder-clay.

Each of the stages was then described separately, with details of exposures and sections throughout the area.

The Early and Middle Pennine Boulder-clays, which closely resembled each other, were regarded as composed of materials derived almost entirely from the Derbyshire mountains, but with a slight admixture, to the westward, of erratics derived from Scotland and Cumberland. The latter were probably brought from those counties by an ice-stream, the main materials of the deposits having been transported from the Pennine chain by glaciers, and deposited in the partially submerged valley of the Trent. The intermediate quartzose sand was deposited in the sea during an intercalated warmer age of considerable submergence.

The Middle Pleistocene deposits, distinguished from the earlier by containing large quantities of chalk and flints derived from the north-east, were apparently formed at a time when the level of the Trent-valley area was lower than that of the Cretaceous tracts in Lincolnshire and Yorkshire. The Great Chalky Boulder-clay was chiefly a ground-moraine formed beneath an ice-sheet on land, but in places presented signs of aqueous origin. The Melton sand, below, in which Cretaceous detritus first appeared in abundance, consisted of stratified sands with occasional beds of gravel or loam, and indicated a less extreme temperature. In West Staffordshire the gravels and sands probably represented the entire Middle Pleistocene deposits, no great Chalky Boulder-clay being found, and in this area fragments of marine mollusca were of frequent occurrence. The Chalky Gravel was also a marine deposit, and, like the Melton Sand, was probably formed when the temperature was rather milder than it was during the deposition of the Great Chalky Boulder-clay.

In the Newer Pleistocene epoch re-elevation of the Trent valley and of the Pennine chain appeared to have again produced a change in the direction from which the materials of the deposits were derived. The

Interglacial Alluvium was of freshwater origin, but the admixture of Scotch and Cumbrian detritus with that derived from the Pennine range indicated that glaciers from the north again reached the Trent area. A colder age succeeded, during which the Later Pennine Boulder-clay was formed, partly of local materials, partly of erratics from the Pennine range, mixed with a few from Cumberland and even from Wales. This deposit was almost entirely unstratified, and consisted largely of moraine detritus, the ice-sheets having disturbed and rearranged the earlier deposits and mixed them with rock-detritus from the neighbourhood. To this later ice-sheet was attributed the contortion so frequently observed in the Older and Middle Pleistocene deposits. Reasons were given for the opinion that such contortions were due to ice- and not to soil-cap motions or their later agencies.

5. "On the Existence of a Submarine Triassic Outlier in the English Channel off the Lizard." By R. N. Worth, Esq., F.G.S.

Attention was called to the frequent occurrence of sandstone fragments in a certain part of the English Channel, brought up by the fishermen's "long lines." The evidence favours the idea that these rocks are *in situ.*

A list of the specimens found, with bearings and distances, was given; they consist of red, and sometimes greyish sandstones, mostly soft, also marls, "potato stone," and nodules of Triassic trap. The affinities are with the Keuper of Devon. The position deduced from the observations is about 10 miles S.E. of the Lizard, and beyond the 30-fathom line. This submarine outlier is larger than any outlier on the mainland of Devon or Cornwall, and carries the English Trias nearly 50 miles further to the S.W.

ZOOLOGICAL SOCIETY OF LONDON.

April 20th, 1886.—Prof. W. H. Flower, LL.D., F.R.S., President, in the Chair.—The following communication was read:—

3. "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis,* Mackie)." By A. Smith Woodward, F.G.S. Communicated by the Secretary.

In this paper, the author described the mandibular and hyoid arches of *Hybodus dubrisiensis,* as exhibited in a fossil from the Chalk of Kent, preserved in the British Museum. The cartilages are all in an admirable state of preservation, and show that the Cretaceous Hybodont skull made a near approach to the primitive condition termed "amphistylic" by Prof. Huxley (Proc. Zool. Soc. 1876, p. 41). The fossil jaws are also interesting from their close resemblance to those of the Notidanidæ, which are the most amphistylic of living vertebrates; and the pterygo-quadrate cartilage exhibits the facette for a post-orbital articulation with the cranium, which forms so characteristic a feature of the existing family just mentioned. The hyoid elements are likewise remarkably slender. The fossil further shows traces of well-calcified vertebræ, which are astero-spondylic in structure, and are well seen in a second specimen in the National Collection. The latter fact is of peculiar interest, since a fossil from the Lias, with teeth generically indistinguishable, affords distinct evidence of a persistent notochord, with the arches alone calcified; and as three Hybodont pterygo-quadrates of Liassic and Wealden age appear to be destitute of an articular facette where contiguous with the post-orbital region of the cranium, there is also a corresponding indication of progressive development in the mandibular arch. The author also pointed out that the differences between the anterior and posterior teeth are more marked in *H. dubrisiensis* than in any of the earlier forms of which satisfactory remains are known, and concluded by suggesting that future research in regard to structures other than teeth will probably lead to the generic subdivision of the multitudinous forms hitherto grouped under the name of *Hybodus*.

CORRESPONDENCE.

THE SURVEY OF WESTERN PALESTINE.

SIR,—Permit me to offer two or three observations as regards matters of fact in reply to the criticisms contained in the review of the "Geological Memoir on Arabia Petræa and Palestine." The reviewer says (p. 229): "Fossils appear to be rare throughout the [Cretaceo-Eocene] series—the Expedition does not seem to have discovered any in fact." This is really not so. We brought home a good many specimens, and I placed them in the hands of Professor Sollas (who was so good as to describe the Carboniferous forms) for determination. But owing to causes, doubtless quite sufficient, I did not receive the specimens back till too late for publication. Since then Prof. Sollas has informed me that there were no new forms amongst them, as they had already been determined by Lartet and others. It is only known to those who have made the attempt, how difficult it is to collect fossils and specimens when on a journey on camel- or horse-back, through the desert under a temperature of 80° Fahr. in the shade, and 112° in the sun.

Again, in speaking of the "*Calcareous Sandstone of Philistia,*" the reviewer states, "No thickness is assigned to this deposit." I have only to say in reply that owing to the extent to which Philistia is overspread by the deposits of the 220 raised sea-bed—and with loam—the sections of this sandstone are very rare; nor had we any opportunity of observing the junction of the sandstone with the Nummulite-limestone. Both thickness and relations, as they are inferred by me, may be gathered from the horizontal section, No. 1, across Palestine. It is not improbable the formation has a thickness of 300 to 400 feet. The reviewer seems to have overlooked the fact that this sandstone appears to have its equivalent in the series at Mokattam Hill, near Cairo, described by Schweinfurth.

3. As regards the question, "What has become of the materials which have been removed from the surface of the drainage area of the Dead Sea?" (p. 231). As this basin never had an outlet, there can be only one answer (which appears to me self-evident)—that they are either used up in the terraces—or are spread over the floor of the Dead Sea and Jordan-Arabah Valley. The bottom both of

the Dead Sea and of this valley are covered by alluvial deposits. What the thickness of these may be no one knows; nor can the question of the depth to the *solid rocks* below the alluvial materials be solved except by extensive boring operations. In my opinion the depth is very great; and if this be so, the answer to the question of the reviewer is plain,—at least, this is the only answer I conceive possible.

DUNFANNAGHY, 12*th May*, 1886. EDWARD HULL.

THE DEVELOPMENT OF THE NORTH AMERICAN CONTINENT.

SIR,—There are no questions in Geology more important and more fascinating than those of Palæo-geography. All geologists must be grateful to Prof. Hull for the light he has shed upon them. But, also, there are no questions which are more difficult, and the solution of which is more illusory. I would not again trouble you on this subject except to correct what seems to me a grave misconception on the part of Prof. Hull,[1] which lies at the basis of nearly all the difference between us.

He refers to an ideal section of the Palæozoic rocks on p. 288 of my "Elements of Geology" (being a section from Canada through New York to Pennsylvania), as indicating continued *subsidence* of sea-bottom and *retreat of shore-line northward* during the Palæozoic period. This interpretation is the very opposite of that usually given by American geologists. Perhaps the mistake, if it be one, is partly due to bad drawing. In order to bring all the Palæozoic strata within the compass of a small figure, the southward dip is enormously exaggerated. In fact, the strata are nearly level, the average dip being probably not more than 15–20 feet per mile. The successive appearance of younger and younger rocks as we go southward is supposed by all American geologists to indicate a gradual *elevation* of the Canadian land-mass of that time, and a consequent *advance of the shore-line southward with steady increase of land.* This is seen at once if the section be drawn with smaller dips and leaving out details (Fig. 1).

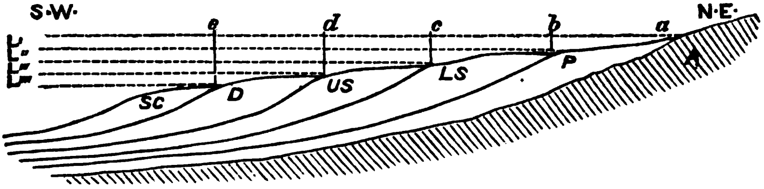

FIG. 1.—Generalized N.E. and S.W. section from Canada through New York to Pennsylvania. *A.* Archæan. *P.* Primordial. *L.S.* Lower Silurian. *U.S.* Upper Silurian. *D.* Devonian. *S.C.* Sub-Carboniferous. *a b c d e* successive shore-lines. $l\ l'\ l''\ l'''\ l'''$ successive sea-levels.

The western shore-line of the *eastern* land-mass was, on the contrary, nearly stationary, and hence the prodigious thickness of Palæozoic sediments in the Appalachian region. Even here, however, whatever movement of shore-line there was, seems to have been westward with increase of land.

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[1] See Prof. Hull's letter, GEOL. MAG. April, 1886, p. 189.

Two other points I briefly touch. Prof. Hull thinks that I do not recognize sufficiently, if at all, his most important point, viz. "the increase of thickness of sediments to the N.E. and E., and their attenuation and replacement by limestone in the opposite direction." If I did not lay stress on this, it was only because I supposed it generally recognized, although Prof. Hull brings it out in a very striking way in his figures. No one has emphasized these facts, and their significance as showing a large land-mass to the north-east and a wide ocean to the south-west, more than I have.[1]

Again, in my previous communication[2] I said, "There is no reason why the eastern land-mass, which sufficed to contribute 30,000 ft. of Silurian and Devonian sediments, should not have been sufficient to contribute the much smaller amount of Carboniferous sediments." Prof. Hull thinks this a begging of the question at issue. For, says he, "the narrow strip of land allowed by Prof. Le Conte was quite insufficient to produce 30,000 ft. of conformable sediments." I can only say in reply that Prof. Hull's map of Silurian times led me astray: for this shows just such a land-mass as I suppose, while his map of Carboniferous times shows a very much greater land-mass. I suppose, now, however, that he imagines this land-mass to have increased on its eastern side through Silurian and Devonian times. If so, it must have increased very rapidly, for the Silurian alone is 20,000 ft. thick in the Appalachian region. JOSEPH LE CONTE.

PERMANENCE OF CONTINENTS & OCEAN-BASINS, WITH SPECIAL REFERENCE TO THE FORMATION AND DEVELOPMENT OF THE NORTH AMERICAN CONTINENT.[3]

SIR,—Will you allow me to make a correction? Prof. Chamberlin has kindly drawn my attention to the fact that in my original communication to you on this subject[3] I have misrepresented him, and I wish therefore to acknowledge my error. The map on p. 62 of Prof. Chamberlin's work on the Geology of Wisconsin was not intended, as I supposed, as a map of Archæan areas, but really as a map of land during a portion of Archæan times, viz. (if I understand him) at the beginning of the period of Huronian sedimentation. I was misled by its great resemblance to the usually recognized map of Archæan areas. The confusion of thought to which I referred does indeed exist, but Prof. Chamberlin is not an example of it.

Let us hope that Prof. Chamberlin will give us more fully his mature views on this so obscure and yet so important subject. No one is more competent than he to write with authority on the subject. JOSEPH LE CONTE.

BERKELEY, CALIFORNIA, *May* 3, 1886.

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[1] Am. Jour. vol. iv. p. 463, 1872. Elements of Geol. p. 289.
[2] See GEOL. MAG. March, 1886, p. 100.
[3] GEOL. MAG. 1886, Dec. III. Vol. III. p. 97.

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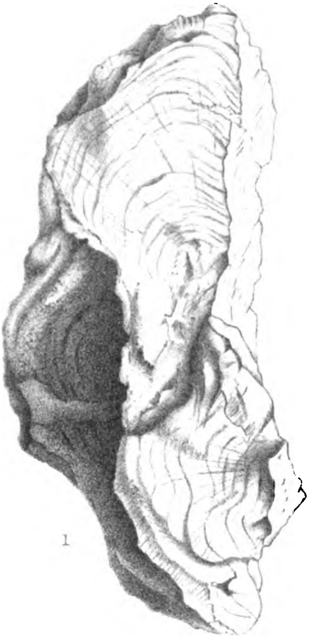

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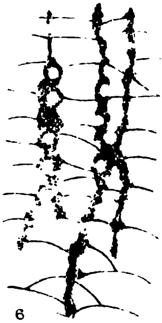

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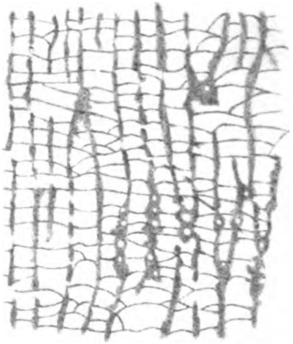

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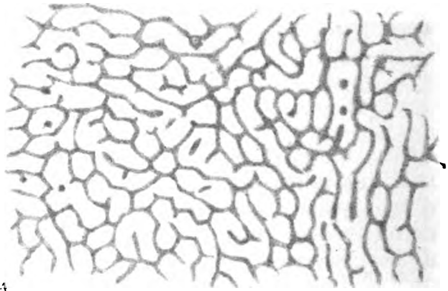

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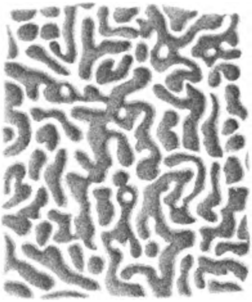

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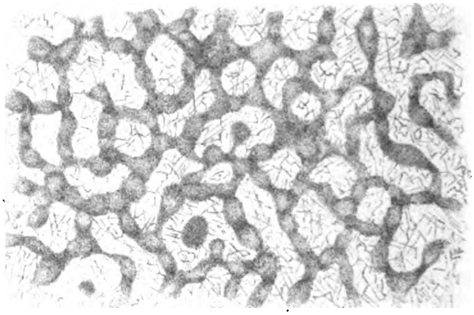

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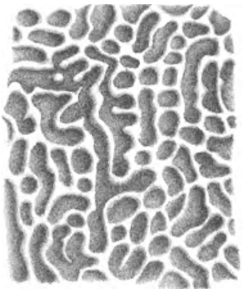

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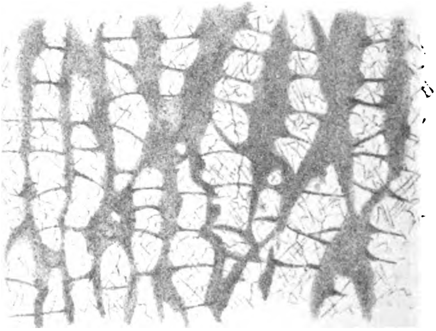

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dopora alveolaris *Nicholson*

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VO

No. VII.—JULY, 1886.

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ORIGINAL ARTICLES.

I.—On *Desmidopora alveolaris*, Nich., a New Genus and Species of Silurian Corals.

By H. Alleyne Nicholson, M.D., D.Sc.,
Regius Professor of Natural History in the University of Aberdeen.

(PLATE VIII.)

Desmidopora, gen. nov.

Gen. Char.—Corallum composite, with an epithecate base, the corallites subpolygonal, and indissolubly united by the coalescence of their walls. The corallites are sometimes circumscribed, but they are for the most part more or less extensively connected by deficiency of their walls in particular directions, so as to give rise to sinuous rows of serially-united tubes. The calices, like the corallites, may be circumscribed, but are mostly in the form of vermiculate grooves corresponding with the serially confluent corallites. The calices are not oblique, nor are the corallites reclined. Mural pores are numerous and well developed. Septa and septal spines are wholly wanting. The tabulæ are numerous, being simple and complete in the circumscribed corallites, but becoming vesicular in the rows of serially confluent corallites. New corallites are produced by fission.

I have found it necessary to propose the above generic name for a remarkable coral from the Wenlock Limestone of Dudley, for specimens of which I am indebted to the kindness of Mr. William Madeley, whose experienced eye had recognized that they belonged to an unusual type. In general aspect, the specimens show resemblances to the laminar forms of both *Alveolites* and *Chætetes*, as also to *Labechia*; and it was to the last of these that I was at first disposed to refer them. A microscopical examination has, however, shown that they are most nearly related in reality to *Alveolites*; the presence of numerous mural pores, quite of the type of these structures in *Favosites* itself, proving that they are indubitably referable to the group of the Favositidæ. The specimens, however, exhibit the following structural peculiarities, which preclude our referring them to any previously-named genus of Favositoid Corals with which I am acquainted:—

(1.) The primordial wall of the corallites is entirely wanting, adjoining visceral chambers being thus separated by an apparently single wall, as is the case in the genus *Chætetes*, Fischer.

(2.) A certain number of the corallites may have their visceral chambers definitely circumscribed; but others are united in serial rows by deficiency of their walls on corresponding sides. These rows are sinuous; and the calices assume, therefore, largely the form of winding labyrinthine grooves (Pl. VIII. Fig. 2).

(3.) No septa or septal spines are present. In examining the surface of well-preserved specimens one might be easily led to suppose that irregular septa were here and there developed; but these apparent septa are really only the inward projections of the walls of the corallites marking the boundaries of the separate tubes in the serially united rows.

(4.) In the completely circumscribed corallites, the tabulæ are simple, and are either horizontal or are curved with their convexities pointing towards the calices. On the other hand, in the serially united corallites the tabulæ become vesicular by reason of their confluence in adjoining tubes.

(5.) The mode of increase is by fission of the old tubes.

The characters above enumerated form, as before remarked, a combination so peculiar, as to render it impossible to refer the specimens possessing them to any recognized genus of the Favositidæ. I therefore propose for their reception the new genus *Desmidopora*. The essential distinction between this genus and all the normal genera of the Favositidæ is the fact that in *Desmidopora* the mode of growth is fissiparous, and that many of the corallites are thus confluent in serial rows. Apart, however, from this fundamental distinction, there are minor features which separate the present type from the normal genera of the Favositidæ. Thus, in *Favosites* itself there is a persistent primordial wall to the corallites, and septal spines are usually present; whereas in *Desmidopora* the walls of adjoining tubes are indistinguishably fused together, and no traces of septal structures can be detected. In *Pachypora*, Lindstr., again, not only is there a persistent primordial wall to the corallites, but each visceral chamber is contracted by the development of a special secondary lining of sclerenchyma. The genus *Alveolites*, Lam., is separated by the minor peculiarities of the oblique form of the calices and the presence of septal teeth or ridges, while the mural pores are large and uniserial. Lastly, the genus *Laceripora*, Eichw., makes a nearer approach to the present type than is the case with any other known genus of the Favositidæ. Apart, however, from the fundamental point of the fissiparous mode of increase in *Desmidopora*, the genus *Laceripora*, Eichw., is further separated from the latter by the persistent primordial wall of the corallites, the possession of distinct septa, and the fact that a special secondary lining of sclerenchyma is developed in the tubes in the peripheral region of the corallum. In tangential sections of *Laceripora* the visceral chambers of adjoining tubes often become connected by deficiency of the intervening wall; but this is not due—as might easily be imagined—to fission of the tubes. On the contrary, it is simply due to the fact that the section happens to cut at such points across the very large mural pores with which the corallites are provided.

Very closely related to *Laceripora*, Eichw., if indeed really generically distinct from it, is the genus *Somphopora*, Lindstr. ("Obersilurische Korallen von Tshau Tiën," p. 51, pl. vii. figs. 2—5); and this, therefore, also presents some resemblances to *Desmidopora*. In *Somphopora*, however, the primordial wall of the corallites is persistent, and well-developed septal structures are present, while the mural pores are of very large size, points quite sufficient to prove its distinctness from *Desmidopora*.

Beyond the limits of the Perforate Corals, the only genus with which *Desmidopora* need be compared is *Chætetes*, Fischer. In general aspect there is a decided resemblance between *Desmidopora* and some of the species of *Chætetes;* and the fissiparous mode of increase is a structural feature common to the two genera. There are, moreover, species of *Chætetes* (such as *C. Etheridgii*, Thoms. sp.) in which the corallites in the process of fission become often laterally elongated, and the calices are therefore commonly compressed and sinuous. The presence of numerous well-marked mural pores in *Desmidopora* is, however, of itself sufficient to separate the present genus wholly from *Chætetes*, Fischer.[1]

The only species of *Desmidopora* with which I am acquainted occurs in the Wenlock Limestone of Britain, and possesses the following characters:—

DESMIDOPORA ALVEOLARIS, Nich.

Labechia alveolaris, Nich., Mon. Brit. Stromatoporoids, p. 83 (name only), 1886.

Spec. Char..—Corallum in the form of a laminar expansion, which may reach half a foot in diameter, and which varies in thickness from less than a centimetre to two centimetres. The corallum was attached to some foreign body by a peduncle, and the base is covered by a concentrically wrinkled epitheca (Pl. VIII. Fig. 1). The corallites are directed approximately at right angles to the basal epitheca, and are usually from $\frac{2}{3}$ to 1 millim. in diameter. The calices are variable in shape, but are never oblique or crescentic in form. Parts of the surface generally show many of the calices as as subpolygonal, definitely circumscribed apertures (Pl. VIII. Fig. 3); while in other parts the calices have become more or less extensively confluent, and have the form of winding and sinuous grooves (Pl. VIII. Fig. 2). The tabulæ are numerous, mostly convex, with their convexities turned upwards, and generally about half the diameter of the corallites apart. Very often they are placed at approximately the same level in adjoining tubes; and in the serial rows of corallites they become vesicular. Mural pores are numerous, but not of unusually large size.

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[1] Mr. James Thomson has described mural pores as occurring in *Chætetes Etheridgii*, Thoms. sp., *C. septosus*, Flem., *C. depressus*, Flem., and *C. hyperboreus*, Nich. and Eth., jun.; and he has therefore referred these species to *Alveolites* (Proc. Phil. Soc. Glasg. 1881). I have, however, examined numerous specimens and microscopic sections of all these species, and am quite satisfied that the walls of the corallites are in all of them imperforate. Indeed, the figures given by Mr. Thomson himself show conclusively that the structures which he has described as mural pores could not possibly be of this nature.

The structure of *Desmidopora alveolaris* can be readily made out by means of thin sections, if these happen to be taken from a specimen in which the skeleton has not been much altered by mineralization. In tangential sections of such specimens (Pl. VIII. Fig. 4), the walls of the corallites are seen to be of moderate thickness, and to exhibit no traces of the primordial wall. No traces of septal structures are to be detected, and the visceral chambers of many of the corallites are directly continuous in winding series. In vertical sections (Pl. VIII. Figs. 5 and 6), the mural pores are seen at the points where the plane of the section happens to coincide with the walls of the corallites, and their presence is further recognized by the common occurrence of interruptions to the complete continuity of the walls. Where the section happens to intersect one of the rows of confluent corallites in any direction except a directly transverse one, the tabulæ are seen to be vesicular, but at other points they are as a rule complete.

In other specimens the skeleton has undergone considerable secondary change, and the appearances presented in these cases are to a large extent different to what they are in normal examples of the species. Thus, in such cases (Pl. VIII. Figs. 7 and 8), the walls of the tubes are considerably thickened, and in tangential sections exhibit a peculiar beaded appearance. The same thickening of parts of the walls of the corallites is shown in vertical sections. The first sections which I examined were taken from a specimen which had been mineralized in this peculiar way; and I was led from the phenomena which they presented to regard the species as being a peculiar form of *Labechia*, which I named *L. alveolaris*, without giving any fignre or description of it (Mon. Brit. Stromatoporoids, p. 83). Such sections do, in fact, show a curious likeness to *Labechia*, and particularly to certain specimens of *L. conferta*. It need hardly be said, however, that an examination of sections of a well-preserved example of *Desmidopora alveolaris* leaves us in no doubt as to the systematic position of the species.

Formation and Locality.—Rare in the Wenlock Limestone of Dudley. I am indebted for all my specimens to the kindness of Mr. William Madeley, of Dudley.

EXPLANATION OF PLATE VIII.

Fig. 1. Under side of a broken specimen of *Desmidopora alveolaris*, Nich., of the natural size, showing the epitheca.

,, 2. Part of the surface of the same, enlarged six times. In the portion figured most of the calices are confluent.

,, 3. Another part of the surface of the same, enlarged six times. In this portion of the surface a good many of the calices are definitely circumscribed.

,, 4. Tangential section, enlarged six times. The specimen from which this was taken is but slightly altered by mineralization.

,, 5. Vertical section of the same specimen, enlarged six times.

,, 6. Part of the preceding section, enlarged twelve times, showing mural pores.

,, 7. Tangential section of a mineralized specimen, enlarged twelve times. The appearances presented in this section are not at all unlike those exhibited by some forms of *Labechia*.

,, 8. Vertical section of the preceding specimen, enlarged twelve times. Here, again, the appearances are very like those shown by vertical sections of *Labechia conferta*, Lonsd.

II.—ESSAYS ON SPECULATIVE GEOLOGY.

1.—ON HOMOTAXIS AND CONTEMPORANEITY.

By R. D. OLDHAM, A.R.S.M.,
of the Geological Survey of India.

IN any inquiry into the history of the earth as a whole, we are met at the outset by a serious difficulty. In human affairs a general view of history, not confined to a single country, would be practically impossible, were we ignorant of the relations of the various eras from which different races reckon their dates: thus, it would be impossible to write a connected account of the history of Europe in the classical period were it not possible to determine the relation of the Olympian era to that dating from the foundation of the city of Rome. Yet the supposed case is not unlike that to which the geologist addresses himself when he endeavours to make a connected survey of such widely-separated regions as Europe, India, Australia, and America.

In the supposed case of the Greek and Roman eras, there are numerous points of contact, principally dates of battles, which, having been recorded by both nations according to their own system, enable us to compare the two, and so to determine what would be the date of any event, recorded by the one, had it been recorded by the other. But in geology we have no such points of contact; there is a very general tendency to regard any two series of beds, in which a few fossil forms specifically identical are found, as of contemporaneous origin. That this view is erroneous, and that it would be nearer the truth to say that two widely-separated beds, in which the same forms are found, could not be of *contemporaneous* origin, was long ago pointed out by Forbes and Huxley, the word *homotaxis* being invented by the latter to express the relation existing. More recently, at the Montreal meeting of the British Association, Dr. Blanford went into the question at length, and fully showed how erroneous is the assumption, often tacitly made, that similarity of included organic remains indicates contemporaneity of origin of the beds in which they are preserved.

Be it understood that I am in no way desirous of depreciating the value of palæontological evidence; but, for the purpose of what may be called historical geology, the merely approximate contemporaneity indicated by homotaxis, however perfect, is by no means sufficient. What we desire is something approaching to the accuracy of dates in written history, rather than that vague "homotaxis" indicated by the Stone or Bronze ages, with which we have to be satisfied in what is known as the Pre-Historic period of human history. As long as we are dealing only with the history of a single limited region, no serious difficulty is likely to arise; but when we try to bring the history of, say, Australia and Europe, into relation with each other, a doubt may well arise as to whether beds which would be classed as Lower Carboniferous if they occurred in Europe can be really considered as of that age when measured by European standards.

This is a question that palæontology alone can never answer finally, and we are consequently compelled to search for some other evidence which will enable us to say, in some cases at any rate, that the beds are or are not strictly contemporaneous in their origin. One possible means would be the traces left by a period of cold similar to the well-known "Glacial period" of Post-Tertiary times. That there was such a period during which an arctic climate penetrated into temperate regions has been amply proved, and we may, I think, safely assume that this "Glacial" period of cold was contemporaneous in both hemispheres; for, whatever may have been the cause of the colder climate which prevailed during that period, it must have affected both hemispheres in the same manner at the same time.

I am not overlooking the fact that the most probable theory of the Glacial period, that of Dr. Croll, necessitates the glaciation of one hemisphere contemporaneously with the prevalence of a mild climate in the other; but if we take the Glacial period as a whole, which includes all the minor glacial and interglacial periods, we may say that the Post-Tertiary deposits which show signs of a colder climate than now prevails are of contemporaneous origin, wherever they may be found. By this I must not be understood to mean that any one particular bed in one place can be declared to be contemporaneous with a definite bed anywhere else, but that the series as a whole were of contemporaneous origin, though the actual limits may not have been the same in both cases.

If we can prove that similar Glacial epochs have occurred during the sedimentary period, using the term to denote that period of the Earth's history which is represented by the sequence of sedimentary formations, we shall have an important check on the palæontological timepiece, by which we can determine whether it is fast or slow. To prove this it will not be sufficient merely to point out that evidences of glacial action have been detected by various observers in strata of various ages, and in latitudes lower than those in which icebergs are met with at the present day; but if it can be shown that, in several widely-separated regions, and in strata which can on independent grounds be shown to be, at least, approximately homotaxial, there are to be found extensive indications of glacial action, which are not seen in the beds above or below, we may safely and fairly conclude that they all belong to a single Glacial epoch comparable to that of Post-Tertiary times.

For this purpose I shall take that Glacial period represented by the Talchir beds of India, the Ecca beds of Africa, and certain beds in Australia likewise of glacial origin. I choose this particular instance because the details are more familiar to me than any other, and moreover I shall be able to place before the readers of this MAGAZINE some recent additions to our knowledge of the geology of these countries.

It must be well known that there have been serious differences of opinion regarding the age of the Indian and Australian Coal-measures, and that this difference has practically been between the field geologists on the one hand and the palæobotanists on the other. The former regarded them as of Carboniferous age, or, at the latest, representing the interval between the Palæozoic and Mesozoic eras of Europe, while the latter, judging only from the plant remains found with the coal, declared it to be of Mesozoic and even of Jurassic age.

As regards the palæontological relations of these beds to each other, and to the plant-bearing series of South Africa, the subject has been so thoroughly treated by Dr. Blanford in his address that it will be needless for me to enter into a repetition of the subject. I may, however, remark that both in India and South Africa there is a series of sedimentary formations which, if identity of fossils were proof of contemporaneity, would have to be regarded as of contemporary and even coeval origin, and in both cases there are at the lower limit of the series beds whose structure proves that they must have been deposited through the agency of floating-ice. In Australia there are some beds (the Bacchus Marsh beds of Victoria) which similarly show that there must have been ice floating in large masses on the sea beneath which they were deposited: these beds have yielded a limited flora composed of three species of *Gangamopteris*, of which one is identical with and the other two closely allied to Talchir species.

Thus we see that in India, in South Africa, and in Australia there are beds whose nature indicates the existence of ice floating at or near the sea-level, in latitudes which it does not now reach, and that, as judged by the fossil plants contained in them and in the associated beds, they must be regarded as homotaxial. The conclusion is well-nigh irresistible that they all belong to a single Glacial epoch, and are consequently strictly contemporaneous in origin.

So far, I do not think any one will object to my conclusions; they have been foreshadowed by Mr. H. F. Blanford,[1] and as far as India and Australia are concerned by Dr. Feistmantel,[2] who is by no means disposed to underestimate the value of palæobotanical evidence, even where opposed to every other consideration; and so far I have been able to accept and summarize Mr. Blanford's address. But in extending the same line of reasoning, and in trying to determine even approximately the true date of this Glacial period, I shall have to enter on more disputable ground, and to refer to information acquired since Dr. Blanford's address was delivered.

The first point to notice is that the Bacchus Marsh beds of Victoria are not the only instance of Glacial boulder-beds occurring in Australia; for in New South Wales traces of Glacial action are abundant in the marine beds below the Coal-measures. I am not aware of any published record of this fact previous to my own notice of the fact[3]; but, as long ago as 1861, the lithological resemblance, as seen in a collection of specimens from New South Wales, between the marine beds of the Wollongong district and the boulder-beds of the Talchirs, was noticed by the late Dr. T. Oldham.[1] That any special stress should have been laid on the resemblance was not to be expected, for when the words were written the Glacial origin of the Talchir boulder-bed had not been universally acknowledged, the very idea of a Glacial epoch was still strange, and no one had yet dreamed of a Palæozoic Glacial epoch, still less of using such a conception in the correlation of distant deposits. These observations appear to have dropped completely out of sight, and when I found that in Mr. W. T. Blanford's reply to Dr. Feistmantel[2] no notice was taken of this resemblance, although Mr. H. F. Blanford's suggestion that the Glacial beds of the Permian in England and the Talchirs in India were contemporaneous is quoted, I concluded that private information of later date had led to a modification of the views expressed as to the lithological resemblance of the beds.

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[1] Quart. Journ. Geol. Soc. Lond. vol. xxxi. p. 519.

[2] Proc. Geol. Surv. Ind.

[3] Proc. Geol. Surv. India, vol. xix. p. 43 (1886). The substance of this paper and of another in the Journ. As. Soc. Beng. for 1884, is incorporated in the present essay.

Nevertheless, when visiting Australia in 1885, I determined to pay special attention to this point, and was not surprised, on examining the section west of Newcastle, to find that the marine beds showed abundant traces of Glacial action. Blocks of slate, quartzite and crystalline rocks, for the most part subangular, are found scattered through a matrix of fine sand or shale, which contain delicate *Fenestellæ* and bivalve shells with the valves still united, showing that they had lived, died and been tranquilly preserved where they are now found, and proving, as conclusively as the matrix in which they are preserved, that they could never have been exposed to any current of sufficient force and rapidity to transport the blocks of stone now found lying side by side with them. These included fragments of rock are of all sizes, from a few inches to several feet in diameter, the largest I saw being about four feet across in every direction as exposed in the cutting, and of unknown size in the third dimension; and I was informed by Mr. Wilkinson that in these same beds he has seen boulders of slate, etc., whose dimensions may be measured in yards.

It is impossible to account for these features except by the action of ice floating in large masses,[3] and I had the good fortune to discover, during the course of a short morning's walk, in the railway cutting near Branxton, a fragment beautifully smoothed and striated in the manner characteristic of glacier action, besides at least two others which showed the same feature, though obscurely. This seems to show that the ice was of the nature of icebergs broken off from a glacier which descended to the sea-level.

Beds of similar structure and indicating a similar mode of origin are also found at Wollongong, south of Sydney, and in the Blue Mountains. Though these have not been traced into connection with the marine beds west of Newcastle, the similarity of their position, fauna, and physical aspect, all leave little room for doubt that they are of the same age. Beds of similar aspect have been described by Mr. R. L. Jack, in Queensland. These beds—also of marine origin, and indicating the presence of ice floating in the sea by which they were deposited,[1] contain 22 species of fossils, so far as the fauna is known, of which 15 are also found in the marine beds of New South Wales, and only seven have not been found to the south.

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[1] Mem. Geol. Surv. Ind. vol. iii. p. 209 (1863).

[2] Rec. G. S. I. vol. xi. p. 148 (1878).

[3] Roughly speaking, it may be said to take 26 cubic feet of fresh-water ice floating in sea-water to float a cubic foot of granite, or 14 cubic yards to float one ton. It must be remembered that many of these fragments probably came from a distance, and that the ice was melting all the while. These figures must be reduced by two-fifths if the rock is supposed to be immersed.

As the case stands, there are in Australia two sets of beds, both of which indicate the presence of floating-ice in the water in which they were deposited. One of these, the Bacchus Marsh group, is shown by its plant fossils to be homotaxial with the Talchir group of India; the other has yielded a marine fauna of Lower Carboniferous facies, as judged by European standards, and a limited flora which, however, does not show any direct relation to that of the Bacchus Marsh beds.

I am not aware of any published attempt to correlate the Bacchus Marsh beds with a definite horizon in New South Wales before Dr. Feistmantel in 1880 gave it as his opinion that they were the equivalents of the Hawkesbury Sandstones. This opinion, so far as I can glean from his published writings, was based on the so-called Lower Mesozoic facies of the Bacchus Marsh flora, and was supposed to be confirmed by Mr. C. S. Wilkinson's discovery of glacial action in the Hawkesbury Sandstones. Mr. Wilkinson thus describes this evidence[2]—"In the sections exposed in the quarries at Fort Macquarrie, Woolloomooloo, Flagstaff Hill and other places, may be seen angular boulders of shale[3] of all sizes up to 20 feet in diameter, imbedded in the sandstone in a most confused manner, some of them standing on end as regards their stratification, and others inclined at all angles. They contain the same fossil plants that are found in the beds of shale from which they have evidently been derived. These angular boulders occur nearly always immediately above the shale-beds, and are mixed with very rounded pebbles of quartz; they are sometimes slightly curved as though they had been bent while in a semiplastic condition, and the shale-beds occasionally terminate abruptly as though broken off."

It is difficult, if not impossible, to account for these appearances, except by the action of ice in some form or other; the angular form of the fragments of shale shows that in some manner they must have been indurated before disturbance, and it is impossible to account for this induration of what must then have been recently deposited mud except by the freezing of the interstitial water. This supposition would accord with the general nature of the evidence, which indicates the action of ground-ice, such as is formed during the severe winters of North America, rather than the presence of large masses of floating-ice; and hence does not necessarily indicate so severe a climate as that afforded by the Bacchus Marsh beds of

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[1] Report on the Bowen River Coal-field, by R. L. Jack, Esq., F.G.S., Brisbane, 1879.

[2] Notes on the occurrence of a remarkable boulder in the Hawkesbury Rocks, Trans. Roy. Soc. N. S. W. xiii. 105 (1884).

[3] Which is interbedded with the sandstones.

Victoria, which, according to the late Sir R. Daintree, contain "strata, mainly composed of fine mud, dotted thoughout with various-sized, generally rounded, pebbles, and those pebbles mostly unknown in the vicinity, and some not yet seen in place so far as the Geological Survey has extended a minute examination[1];" further on he says that "blocks of granite, in some instances over a ton in weight, are found imbedded in a matrix of soft mud[2];" and in the last progress report by the Secretary for Mines in Victoria, Mr. Murray states, on the authority of the late Sir R. Daintree, that some of these granite boulders resemble no granite that occurs as a rock-mass nearer than Queensland.[3]

This contrast in the nature of the evidence of glacial action shows that, if this form of argument is at all admissible, it is with the Lower Carboniferous marine, rather than with the Hawkesbury glacial beds that we must associate those of Bacchus Marsh.

Nor can palæontology be said to support Dr. Feistmantel's hypothesis; for *Gangamopteris*, the only genus of plants known from the Bacchus Marsh beds, is found neither in the plant-bearing beds, interstratified in the Lower Carboniferous marine group, nor in the Hawkesbury group. It has, however, been found in the intervening Newcastle group, and one species is identical with a Bacchus Marsh form; moreover, the only other species of *Gangamopteris* in the Newcastle beds is, according to Dr. Feistmantel, closely allied to one of the Bacchus Marsh species. This fossil evidence would by many be regarded as sufficient to prove the contemporaneity of the Bacchus Marsh and Newcastle groups; but the beds of the latter show no trace of glacial action, so that the former cannot be referred to that age in face of the existence of evidence of glacial action in the beds above and below. A reference to Dr. Blanford's address will show that whereas a very close relationship exists between the floras of the Newcastle and Lower Coal-measures, there is next to none between those of the former and the Hawkesbury Sandstones; and I may add that the stratigraphy of the beds appears to point to the same conclusion as the palæontology; so that, as the choice lies between the two, it is again rather with the Lower Carboniferous marine than with the Hawkesbury group that we must associate the Bacchus Marsh beds.

The Bacchus Marsh beds are not known to occur in conformable contact with any other group; but there is a large tract of country covered by an upper group of the same series, which is characterized by the occurrence of *Tæniopteris Daintreei*, a form which occurs in New South Wales in the beds overlying the Hawkesbury and Wianamatta groups. Owing to the large area covered by more recent lava flows, the exact relation of the two groups is unknown; but there can be little doubt that they are unconformable, for the Bacchus Marsh beds are overlapped by the *Tæniopteris* beds, which rest unconformably on the older Palæozoics. This would imply a greater difference of age than seems to obtain between the Hawkesbury and overlying groups in New South Wales. To this I may add the difference in induration of the two, which is such that when originally surveyed, the Bacchus Marsh beds were believed to be Devonian, and are coloured on the original survey sheets as Upper Palæozoic.

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[1] Geological Survey, Report on the Geology of the District of Ballan, by Richard Daintree, p. 10, Melbourne, 1866.

[2] *Ibid.*, p. 10.

[3] Geological Survey, Progress Report by the Secretary for Mines, p. 80, Melbourne, 1881.

As a further confirmation of the opinion ventured on, I may point to the relationship that exists between the flora of the Damudas which overlie the Talchir group in India, and that of the Newcastle beds, which occupy a similar position above the Lower Carboniferous marine group in Australia.

To begin with, both floras are marked by the predominance of the genus *Glossopteris*, which, in the Newcastle flora, comprises nine out of 26 species, or 35 per cent. of the total number of species, and 19 species out of 63, or 30 per cent. of the total number of species in the Damuda flora; of these, one species, *G. browniana*, is identical in both cases, and three Newcastle species, *G. linearis*, *G. ampla*, and *G. parallela*, are represented by the allied Damuda species, *G. angustifolia*, *G. communis*, and *G. damudica*. The genus *Phyllotheca* is represented in both floras, and the Australian form is allied to, and was long considered identical with, the *P. indica* of the Damudas. *Vertebraria* is found in both series, and is only known elsewhere from the "Jurassic" beds of Siberia. *Sphenopteris alata*, Brong., is another species represented by allied forms in the Damuda flora, and *Gangamopteris angustifolia*, M'Coy, is common to the two floras. Besides these the genus *Noeggerathiopsis* is represented in both floras, so that we have in all six genera and two species common to the two floras, besides five species represented by allied forms. In other words two-thirds of the genera and more than a quarter of the species of the Newcastle flora are represented in that of the Damudas.

Taking all these points into consideration, I think we may safely affirm that the Talchirs of India, the Ecca beds of South Africa, the Bacchus Marsh beds in Victoria, and the Marine beds below the Newcastle Coal-measures in New South Wales, were all deposited contemporaneously, and that during their deposition there prevailed a Glacial epoch comparable to, if not even more severe than, that of the Pleistocene period.

This conclusion brings out the contradictory nature of the Palæontological evidence even more strongly than it was possible for Dr. Blanford to do in his address, for it shows that the coexistence of a Jurassic flora with a Carboniferous fauna was no mere local phenomenon, but that the Jurassic flora had established itself over nearly half a hemisphere, while the Carboniferous Mollusca were still inhabiting the seas.

In the face of this contradiction, it may be allowable to doubt whether either form of palæontological evidence can be regarded as absolutely trustworthy, and to question whether the beds containing the Lower Carboniferous marine fauna may not have been deposited synchronously with the deposition of the Permian Boulder-beds of England, and with certain Boulder-beds which are known to exist in North America at about the same horizon. It is, however, at present impracticable for me to follow up this question for want of access to books of reference; but this is of comparatively minor importance, as my purpose has merely been to show that there have been glacial epochs comparable to that of the Post-Tertiary period; and having shown that such a glacial epoch did at one time affect a large portion of the Earth's surface, it becomes easy to acknowledge that similar periods of cold have occurred before and since, and that we must not attempt to ascribe every occurrence of Glacial beds of Tertiary or Pre-Tertiary age to some merely local cause. And having acknowledged this, we at once obtain what was wanted, a check on the palæontological timepiece, a time-signal on the chronograph of the world.

Note.—A month ago I would have appealed, as proof positive of the contentions stated above, to the discovery in the Salt Range of the Punjab of marine fossils identical with those of the Australian Carboniferous beds. These are derived from beds which exhibit ample proofs of glacial action, and were on that ground assumed by Dr. Waagen to be of the same age as the Talchirs, which he agreed with most of the members of the Geological Survey in regarding as of Palæozoic age. The pebbles in which the fossils were found might in hand-specimens be taken for concretionary nodules, and an imperfect description of their mode of occurrence would support this idea; moreover the coincidence of the fauna and physical conditions with those of the Australian beds is very striking. There was every temptation for me to accept Dr. Waagen's conclusions, but a careful examination of the beds, and of the mode of occurrence of the fossils, has convinced me that this is a mere coincidence, and that the fossils, which occur as transported pebbles, can consequently be of no use in determining the homotaxis of the beds from which they are derived. The stratigraphical relations of these beds are such as to associate them with the Nummulitics; and as boulder beds, presumably of glacial origin, have been recorded by Mr. Lydekker as conformably underlying the Nummulitics of Ladák, there is no difficulty in finding a horizon to which the beds can be referred.

III.—Essays on Speculative Geology.

2.—Probable Changes of Latitude.

By R. D. Oldham, A.R.S.M. etc.

Part I.—Glacial Periods in Low Latitudes.

In my last essay I had occasion to refer to the former existence of icebergs in localities which now lie in latitudes lower than those in which glacial action is known to have reached, even during the last Glacial period. But, surprising as it may be to find evidence of glacial action within a few degrees of, and, as in the case of the Bowen River Coal-field, a few degrees within, the tropics, this sinks into insignificance in the face of the evidences of repeated Glacial periods that may be found in India, and especially in the Himalayas.

In Kashmir Mr. Lydekker has described[1] a group of beds composed of a fine-grained matrix, through which are scattered boulders of crystalline rock; these were considered to be of glacial origin, and indeed it is difficult to conceive of any other satisfactory explanation. This group, the Punjal Conglomerates, has not yet been identified with certainty in the Simla region of the Lower Himalayas; but there is a group of beds whose position and appearance render it probable that they are of the same age.

Above this group, which may represent the Punjal Conglomerates of Kashmir, but separated from them by a considerable though undetermined thickness of beds and an unconformity, comes the Blaini group,[2] which is so unique in its character, and so constant over a large area, that it is most important in unravelling the structure of the hills. It consists of a band, seldom over 30 feet thick, of thin-bedded limestone resting on a "conglomerate," the matrix being usually a fine-grained slate, through which pebbles and boulders of slate and quartzite are scattered. The aspect of the rock is decidedly glacial, and my colleague Mr. C. S. Middlemiss has discovered a pebble scratched in a manner very suggestive of ice action.

Yet higher in the series there is the Mandháli group, which, though it has so far yielded no scratched pebble, is even more conspicuously glacial than the Blaini Conglomerate; and, yet newer, there are at the base of a quartzite series, provisionally known as the Báwars, some beds originally composed of fine sand, through which rounded fragments of quartzite sometimes over a foot in diameter are scattered; these beds are associated with a very coarse-grained arkose, itself indicative of a more severe climate than now prevails in these latitudes, even at an altitude of 15,000 feet. These last two groups have not yet been proved to be distinct; but there is no reason for doubting their distinctness, or suspecting their identity.

All these beds are conspicuously of subaqueous origin, and if we except the Báwar beds—which have so far been identified in one locality only—too widespread in their distribution and too constant in their characters to render it probable that they are of other than marine origin. There are, besides, very good reasons, which it is needless to enter on here, for supposing that all the sedimentary beds of the Lower Himalayas are of marine origin.

In the Lower Himalayas no pre-Tertiary glacial beds of later date than the Báwars have yet been determined; but in Ladak Mr. Lydekker has described a group of beds which he considers of glacial origin, as conformably underlying the Nummulitics.[3]

Leaving the Himalayas, we find in the Salt Range proofs of glacial action at more than one horizon. The newest of these is in the "Olive group," which was originally described as Cretaceous, and lately, on the strength of some *Conulariæ*, identical with species found in Australia, which were supposed to be derived from concretionary nodules formed *in situ*, has been declared to be Carboniferous and contemporaneous with the Talchir group of the peninsula.[1] This last supposition may or may not be true; but, as I have already explained, there can be no manner of doubt that the fossils occur in transported pebbles, and are consequently valueless for determining the homotaxis of this group.[2]

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[1] Memoirs Geological Survey of India, vol. xxii. p. 247.

[2] First described by Mr. H. B. Medlicott, Memoirs Geological Survey of India, vol. iii. pt. 2, p. 30.

[3] Memoirs Geological Survey of India, vol. xxii. p. 104.

Besides the Olive group, Mr. Wynne has described glacial boulder beds in the Speckled and Purple Sandstone groups of the Salt Range,[3] and in the Trans-Indus extension of that range glacial boulder beds[4] crop out from below a limestone of Upper Carboniferous age.

In the peninsula we know of but a single group of glacial beds, but it is not difficult to account for the difference; for, while the extra-peninsular area has yielded an extensive and fairly complete series of marine sedimentary beds, these are conspicuously absent in the peninsular area. The limestone of the Vindhyan series and the Talchir group of the Gondwanas may be of marine origin; but, apart from them, the rocks of the peninsula, where not of volcanic or metamorphic origin, are almost entirely river deposits; so that the absence of any trace of more than a single glacial period is more than possibly due to their records having been destroyed.

These facts are in themselves sufficiently striking and difficult to reconcile with some of the generally accepted hypotheses of geology, but they are emphasized by a detailed examination of two of the instances. To take the Olive group of the Salt Range, boulders and pebbles showing glacial striæ are abundant, and it is by no means unusual to find an irregular-shaped mass of hard crystalline rock with one, and occasionally more than one, of its surfaces ground into a flat facet, smoothed, polished, and striated with nearly parallel striæ.

In the case of the Talchir boulder bed of the peninsula, it has been usual to ascribe its origin to winter coast ice; but the flattened boulders of the Olive group indicate a more prolonged wearing, a greater pressure and a greater constancy of direction of motion than can be accounted for on this supposition. We are consequently driven to the hypothesis that they have been ground by a glacier which descended to the sea-level and gave off icebergs there.

Now the majority of these boulders consists of rocks of recognizably peninsular types, not a few are of a very highly siliceous felsite porphyry, which is at present only known in the Rajputana Desert, and not a single fragment has yet been found which can be declared to be derived from a Himalayan source. Besides this, the pebble band from which the *Conulariæ* referred to above were obtained exhibits certain peculiarities of distribution, which indicate that the source from which the pebbles were derived lay to the southwards.[5]

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[1] Records Geological Survey of India, vol. xix. p. 22.

[2] Ibid. p. 127, *et sequel.*

[3] Memoirs Geological Survey of India, vol. xiv. pp. 87, 93, 214, etc.

[4] Ibid. vol. xvii. p. 239.

[5] Records Geological Survey of India, vol. xix. p. 129.

The boulder bed of the Olive group has not yet yielded any fossils of contemporaneous origin, but it appears to be perfectly conformable to beds of undeniably marine origin, and every argument from analogy is in favour of the supposition that it is itself either of marine or estuarine origin. But, as I have shown above, the land surface of whose waste it is composed lay to the south, so we arrive at the rather startling conclusion that when the beds of the Olive group of the Salt Range were being deposited, *there were glaciers which descended to the sea-level in a region which now lies within* 34 *degrees of the Equator.*

In that great and almost unknown tract lying between the Aravalli Mountains and the Indus, which is comprehensively entitled "Desert" on the maps, there may be found near the town of Pokran, in N. latitude 26° 55′, an old land-surface showing glacial groovings and striæ. These might be ascribed to the action of winter coast ice formed on the margin of a lake or sea; but, in the boulder beds which occur in the neighbourhood, and are without doubt of the same age as the glaciated land surface, there may be found facetted blocks which, like those of the Salt Range, could not be ascribed to anything but glacier action. Moreover, this land-surface is covered in places by a boulder bed with a hard intensely tough matrix, differing from the stratified boulder beds of the neighbourhood in much the same manner as the "till" of Scotland differs from the marine boulder-clays of the Midland Counties; if the hypothesis that the toughness of the former is due to its being a "Grundmoraine" be accepted, it follows that the same explanation will account for the toughness of the boulder beds of Pokran, and we have yet another proof of the existence of glaciers on this old land-surface.

The boulder beds in the Desert have been traced for sixty miles north-east of Pokran; in the vicinity of the old land-surface the boulders are almost exclusively of porphyry and syenite derived from it, but further north blocks of gneiss of the peninsular type become common; and in N. latitude 27° 30′, East longitude 72° 30′, there is a block of very coarse-grained granite, of which 10 feet × 7½ feet × 3 feet is exposed above ground. The nearest source from which this block could have been derived is in the Aravallis full 150 miles away. The age of these boulder beds appears to be the same as that of the Talchirs; the reasons for this conclusion are of a purely inferential nature, but their extent, combined with the distance from which some of the blocks have been transported, as well as their position on the western margin of the peninsular area, point to the conclusion that they are of marine origin; so that here again we have *evidence of glaciers having descended to the sea in a district now less than* 27 *degrees from the Equator.*

PART II.—GENERAL CONSIDERATIONS.

It has long been known that there were ample proofs of the former existence of mild, even subtropical climates within the Arctic circle; but the continuity of this climate, and the absence of any signs of the extreme cold which now prevails in that region, was never fully understood till it was described and emphasized by Baron Nordenskiöld. In a lecture of his published in this MAGAZINE, after reviewing the evidence of the fossil flora and fauna, he remarks on the favourable nature of the country for geological investigation, on the completeness of the series extending one may say from the Silurian to the Tertiary, and emphasizes the fact that, in all the sections he had examined, he never saw a boulder "even as large as a child's head" in any rock of Tertiary age or older.[1] Various hypotheses have been propounded to account for these warm climates in the Arctic regions without involving a shifting of the earth's polar axis; the most ingenious and captivating of these is doubtless Mr. Wallace's modification of Dr. Croll's theory, according to which the mild climates of the polar area were due to the warming effects of currents of heated water, from the equatorial regions, which have been cut off by a gradual development of the continental areas. Looked at from the polar point of view, this hypothesis was legitimate and competent enough to account for the facts it was intended to explain; but an hypothesis is only acceptable as long as nothing directly incompatible with it is known, and however competent the hypothesis may be to account for the mild climates of what are now the Arctic regions, it is absolutely incompatible with the evidences of repeated glaciation in low latitudes which I have referred to above.

Mathematicians forbid us to explain the circumstances by a shifting of the axis of revolution of the earth. Whether in this they are right or wrong is immaterial, for it seems to me that there is an equally satisfactory hypothesis open to us. Mr. Fisher, in his "Physics of the Earth's Crust," has given good reasons for supposing that there is a fluid or semifluid layer intervening between the solid core and the solid crust of the earth,—in other words, that the latter has a power of shifting its position on the former; if this theory be accepted, it is quite conceivable that the portion of the earth's crust which now occupies the polar circle may once have lain under the Equator and *vice versa*; indeed I find in Mr. Fisher's[2] book an assertion of the probability of this shifting of the polar and equatorial areas based on reasons quite different from and independent of those I have given for the same conclusion.

The known facts of stratigraphical geology, more especially the existence of regions which can be proved to have undergone compression to the extent of two or more times their present dimensions, in immediate proximity to others in which the beds have suffered little or no compression, show that to some extent this shifting of the crust of the earth over its core must take place, and almost the only argument that can be produced against an extension of the same reasoning would be derived from the doctrine of permanence of continents. It is, however, by no means inconceivable that the two hypotheses might be quite consistent; were the differences between the continental and oceanic areas entirely due to differences in the structure of the crust, the latter might shift its position relative to the core to any extent without interfering with the relative positions and forms of the continental and oceanic areas.

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[1] GEOL. MAG. 1875, p. 531, and 1876, p. 266. I cannot help contrasting this with my own experience in the Himalayas, where the series is well exposed in numerous deep valleys, where there is an extensive series of beds extending from even before the Silurian to the Tertiaries, and where evidences of pre-Tertiary glacial action met me, I might almost say at every turn.

[2] Physics of the Earth's Crust, p. 184. But earlier still see "On a Possible Cause of Climatal Changes," by Dr. John Evans, F.R.S., F.G.S., GEOL. MAG. 1866, p. 171.—EDIT.

But is this doctrine so well established that it can be used as an argument against any hypothesis which is fairly supported by known facts? I think not. It is unnecessary to refer to the fact that the "Oceanic" island of South Georgia has been found to consist of clay-slate,[1] and not of volcanic rocks, as *ex hypothesi* it should, for there are certain peculiarities, in the palæontology of India and South Africa, which indicate the former existence of direct land communication between the two countries. This was first pointed out by Mr. H. F. Blanford, whose paper is somewhat contemptuously dismissed by Mr. Wallace with the remark that "the notion that a similarity of the productions of widely separated continents at any past epoch is only to be explained by the existence of a direct land connexion, is entirely opposed to all that we know of the wide and varying distribution of all types at different periods, and is no less opposed to what is now known of the general permanency of the great continental and oceanic areas."[2] This, however, implies a misconception of the nature of the evidence, which is far from being based merely on a "similarity of the productions" of the two countries. There are in Africa two distinct floras of different ages; one of these, that of the Beaufort beds, has a flora consisting of five distinct species, of which one is identical, two are closely allied to, forms found in the Damuda beds of India, and if we accept Dr. Feistmantel's[3] opinion, all belong to Damuda genera; associated with these plants is an extensive and peculiar reptilian fauna, of which the most prominent genus is *Dicynodon*, a genus at present unknown elsewhere except from the Panchet beds which overlie the Damudas, and another form, *Micropholis Stowei*, is a near ally of *Brachiops laticeps* from the Kamthi beds of Mangli.[4]

At a higher horizon in South Africa, in the Uitenhage formation, there is a flora consisting of 12 distinct forms, all generically different from any of the Beaufort species. Of these, one is identical with, four are closely allied to, species from the flora of the Rajmahal group in India. The difference between the flora of the Rajmahal group and of the Danudas is almost as great as in the case of the two corresponding African groups, for there are only three species in the Rajmahal flora which are in any way allied to any of the Damuda plants. We have then a close and continuous similarity between the fauna and flora of two countries lasting through a period long enough to allow of a complete specific, and almost complete generic change.

A similar but even more conclusive argument may be derived

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[1] Nature, March 27, 1884, p. 509; Geol. Mag. Dec. III. Vol. I. p. 225 (1884).

[2] Island Life, p. 398.

[3] Palæontographica, 1878, p. 114.

[4] Manual of the Geology of India, vol. i. p. 123.

from the relations of the Marine Cretaceous rocks in India and other parts of the world. Both in Southern India and Southern Africa there are marine deposits of Cretaceous age, with regard to which Dr. W. T. Blanford writes in the Manual of the Geology of India as follows:—"Before quitting the subject of the Trichinopoly Cretaceous beds, it is necessary to notice the very remarkable resemblance between a portion of their fauna and the species found in certain strata in Southern Africa. In the description of the Gondwana system, and again in the account of the Upper Jurassic beds of Cutch, the remarkable affinities between Indian fossil plants and animals, and the forms found in South African beds, were repeatedly noticed, and there is a similar connexion between the Cretaceous formation in the two regions. In some deposits found resting upon Karoo beds on the coast of Natal, out of 35 species of *Mollusca* and *Echinodermata* collected and specifically identified, 22 are identical with forms found in the Cretaceous beds of Southern India, the majority being Trichinopoly species. . . . .
The South African beds are clearly coast or shallow-water deposits, like those of India, and the great similarity of forms certainly suggests continuity of coast-line between the two regions, and thus supports the view that the land connection between South Africa and India, already shown to have probably existed in both the Lower and Upper Gondwana periods, and of which important indications are afforded by the Marine Jurassic beds, was continued into Cretaceous times. It is very surprising to compare the Middle Cretaceous fauna of Southern India with that of the distant beds of Natal, and then with the widely differing forms found in beds of the same age *in Central India and Southern Arabia.*"[1]

Speaking of the latter he says, "Some of the species have a wide range in time among the Cretaceous rocks of Europe, but all occur in the Upper Greensand (Cenomanian), many being characteristic forms, and the Cretaceous rocks of the Narbadda valley must in consequence closely correspond to the Utatur group of Southern India. It is curious to note that, so far as is known, only one species, *Pecten* (*Vola*) *quinquecostatus*, is common to both, and even in this case the identification depends upon a question as to which palæontologists are not thoroughly agreed . . .

In strange contrast with the wide difference between the known fauna of the Bagh beds and that of the Southern India deposits is the similarity between the fossil remains of the Narbadda valley and those found in two localities on the south-east coast of Arabia. The collections examined from both localities are small, and were obtained in each case during a short visit; but although the united Arabian collections only comprise 13 species and the Bagh 12, three of these . . . . are common to the two countries. The Cretaceous beds of the lower Narbadda valley are about 750 miles distant from those of Southern India, and twice as far from the Arabian localities. The marked contrast between the fossil faunas in the one case, and the similarity in the other, tend to suggest the probability that a land barrier interposed in Middle Cretaceous times between Southern India with Assam and Arakan on the one side and the Western Narbada region with the south coast of Arabia on the other. We have thus another argument presented to us in favour of the Indian peninsula being portion of an ancient land-area; and taking into consideration the marked connexion between the faunas of the South Indian and South African Cretaceous deposits, and the circumstance that both appear to be of littoral origin, it is probable that this land-area extended to Africa."[1]

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[1] *Loc. cit.* p 292.

These facts indicate that the permanence of continents is a hobby which some of its admirers have ridden too hard, and at any rate prove that it cannot be used to stifle a plausible hypothesis.

Another group of facts which are in favour of the suggestion I have made above is the observational evidence in favour of a change of latitude in some of the principal European observatories. In the American Journal of Science for March, 1885, Professor Asaph Hall gives, on the authority of S. Fergola, the following table of latitudes of the principal observatories of Europe and America:—

Washington	1845	......	38° 53′ 39″·25
do.	1863	......	38″·78
Paris	1825	......	48° 50′ 13″·0
do.	1853	......	11″·2
Milan	1811	......	45° 27′ 60″·7
do.	1871	......	59″·19
Rome	1810	......	41° 53 54″·26
do.	1866	......	54″·09
Naples	1820	......	40° 51′ 46″·63
do.	1871	......	45″·41
Königsberg	1820	......	54° 42′ 50″·71
do.	1843	......	50″·56
Greenwich	1838	......	51° 28′ 38″·43
do.	1845	......	38″·17
do.	1856	......	37″·92

Besides this there are the Pulkowa observations which give the following results:—

Pulkowa	1843	......	59° 46′ 18″·73 ± 0″·013
do.	1866	......	18″·65 ± 0″·014
do.	1872	......	18″·50 ± 0″·014

I am aware that the most recent investigations of the Greenwich observations by the present Astronomer-Royal have shown that there is no proof of continuous change of latitude; but it is surely something more than a coincidence that the change in every case is in the same direction; had the change been due merely to imperfect observation or the vagaries of refraction, it would hardly have exhibited these strange coincidences. There is, however, more than one way of explaining these slight variations of latitude, and, seeing that the observations extend over a comparatively short period of time, it would not do to attach too great importance to them in this connexion.

A more important argument is to be derived from the careful measurements of the pyramids of Gizeh which have been made by

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[1] *Loc. cit.* p. 297.

Mr. Flinders Petrie. The orientations of the sides and passages of the great and second pyramids vary not more than 30″ from each other, but they both agree in varying rather than 5′ west of north;[1] it is inconceivable that this close approximation of the orientation of the sides and passages of these pyramids should be due to accident, nor is it conceivable that the builders would deliberately have introduced a variation of some 5′ west of north. A far more probable explanation is that owing to a shifting of the earth's crust on its core, or of the axis of revolution, there has been a variation of that amount in the direction true north since the pyramids were built.

Such, briefly stated, are the conditions of the problem. We have first a group of facts inexplicable, unless we grant the possibility of a shifting of the earth's crust on its core, or of the axis of revolution of the earth; secondly a group of facts inconsistent with the only hypothesis that could be urged against the first supposition, and thirdly a group of facts directly confirmatory of the latter.

In conclusion I must apologize for any injustice I may have—unintentionally—committed; an official geologist in India has to contend with many difficulties, not the least of which is the impossibility of keeping abreast of current literature, and a want of leisure for pursuing independent investigations. It had been my intention to work out this problem more thoroughly during the current year; but having been deputed to accompany an embassy to Tibet, the opportunity is gone, and not likely to recur for some years. I am consequently induced to put my notes on the subject together, somewhat hastily I confess, as it has been my good fortune to meet with a number of facts which cannot be ignored in any discussion of the problem of geological climates, many of them having either never been published at all, or only in a form not generally accessible to European geologists.

IV.—ON THE TUNNEL SECTION NEAR HONITON, DEVON.

By the Rev. W. DOWNES, B.A., F.G.S.

THE writer has for some time hesitated to seek in the pages of the GEOLOGICAL MAGAZINE a publication of his experiences upon the above subject. He fell last year into a grievous mistake with regard to it, and suffered that mistake to be published in the "Transactions of the Devonshire Association for the Promotion of Science, Literature, and Art." It will be his duty, when the opportunity comes round (as shortly it will), to call attention to that mistake in the pages of the same periodical. In the meantime he thinks that the subject, and even the mistake associated with it, may be of something more than local interest. At least the recantation of a published error cannot be too widely circulated.

The tunnel on the L. & S. W. Railway about a mile east of the town of Honiton pierces a hill in a E. and W. direction. The cutting on the W. of the tunnel exposes the Red Marl of the Trias. That on the E. of the tunnel exposes some black or grey beds, mostly arenaceous, which are now to be discussed. Both the Red Marl and the dark-coloured arenaceous beds above them have the same easterly dip of about 5°.

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[1] The Pyramids and Temples of Gizeh, by W. M. Flinders Petrie, p. 125. (London, 1883.)

About a mile to the eastward of the tunnel is a north and south fault, and the tunnel beds are on the downthrow side of it.

Mr. H. B. Woodward and Mr. Ussher had in the work "Geology of England and Wales," p. 237, by the former, expressed an opinion that the beds E. of the tunnel were Gault, and the present writer approached the subject with a decided predisposition in favour of that view. He did not perhaps attach the weight to their opinion that he ought to have done, for he had somehow arrived at the impression that their opinion was but a conjecture, and did not profess to be more. Nevertheless, he would have much hesitated to call it in question, were it not that a piece of entirely new evidence was presented to him.

In the course of correspondence with the railway officials, he was informed that at the Engineer's office of the Railway Company there was a detailed diagram of the tunnel on a large scale. He went to see it, and was brought face to face with a dilemma. Either the black beds were Rhætic, or the diagram was wrong.

Could the latter be wrong? The unknown engineer who constructed it had had exceptional facilities for accuracy. Shafts had been sunk at frequent intervals, and the position, thickness, character, and colour of every bed was given with great exactness. Many thousands of pounds had depended upon the general accuracy of the section, and though the uppermost beds did not affect the tunnelling, it was but reasonable to suppose that they also would be correctly given. And in them was represented an unconformity exactly like that which exists between the Trias and the Greensand in all the country round about, the Trias (or Rhætic) dipping eastward, the Greensand above it being horizontal.

A great unconformity in the midst of the Cretaceous series was not to be thought of. If then the diagram was right, the lower beds could be nothing else but Rhætic. And such the present writer considered them to be until, after a persevering search for fossil evidence, he at last found it; but lo! *the fossils were Cretaceous!*

They were:—

Inoceramus concentricus (Park.) (abundant).
Tornatella (*Actæon*) *affinis* (Sow.)
Pecten quadricostatus (Sow.)
Modiola.
Mytilus.
Tellina.
Exogyra.
Pectunculus.

The above occurred in a black marly clay bed about six feet thick, which comes in the middle of the series.

The diagram, which—tested by the exposed beds at the base—must be accurate in the main, is certainly inaccurate as regards the uppermost beds. As before remarked, they did not affect the tunnelling, and were perhaps carelessly added. Perhaps the designer was in part inspired by the analogy of the surrounding country, with whose geology he was presumably to some extent acquainted. But as his very name is unknown, and he cannot answer for himself, it is useless to discuss his responsibility for the error.

But independently of the diagram, there was a certain balance of other improbabilities which had to be weighed. It was improbable, as urged by Mr. Ussher, that the Rhætic beds should attain so great a thickness,—about 160 feet. It was improbable, as urged by Mr. H. B. Woodward, that they should locally assume an arenaceous character (though, as already mentioned, the beds in question are not arenaceous throughout). But on the other hand, it was improbable that the marked unconformity, usual between the Trias and the Greensand, should be absent in this one spot, that the Trias should have in this particular spot no proper dip whatever; but should acquire just about its normal dip abnormally through the downthrow of a fault, and should exactly share that dip with Cretaceous beds above it.

Again, it was antecedently most improbable that Gault-like rock should reappear in this locality. At Lyme Regis, 25 miles to the S.E., black marl with *Lima parallela* occurs, but this appears to be approaching extinction westward, and is there only about 20 ft. thick. At Uplyme, Trinity Hill, Shute Hill, and Dalwood Down, eminences in a straight line from Lyme Regis to Honiton Tunnel, along the line of dip no Gault is found. And we seek for it equally in vain along the line of strike. Yet at Honiton tunnel something of the nature of Gault is found.

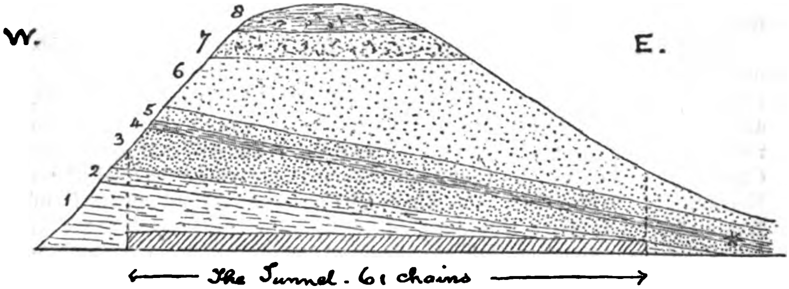
It would seem that to connect these Honiton beds with the Lyme Regis bed, a curved line must be drawn southwards and passing out to sea. Traces of dark grey beds,—all however arenaceous—are seen in the cliff-section at Whitecliff and at Seaton. Further out to sea there might once have been an areno-argillaceous bed connecting the 20 ft. bed of Lyme Regis with the 6 ft. bed of like character at Honiton. It is a conjecture with at least some probability about it.

But when we compare these so-called Gault beds of the West with the typical Gault of Folkestone (Quantum mutatus ab illo!), what have they in common? The argillaceous character has been almost entirely supplanted by an arenaceous one. The fauna has undergone many modifications. *Lima parallela* still lingers on in the attenuated bed at Lyme Regis, but has not yet been found at Honiton, where the semi-argillaceous bed is still more attenuated. Even the colour gets washed out as we go westward. Clay merges into sand. Black merges into yellow. In a word, between Upper Greensand and Gault boundary there is none in the West of England.

With the exception of the unconformity represented in the upper beds of the section, the diagram in the possession of the L. & S. W. Railway is no doubt mainly correct. It gives the following thicknesses to the several beds:—

Clay with Chert passing into Cherty Greensand, bedded ...	55 feet.
Grey Sand	81 ,,
Yellow Sand	18 ,,
Varigated Marly Clay	6 ,,
Black Sand	44 ,,
White Sand	1 ,,
Greenish Sandy Clay	10 ,,
	215 ft.
	Red Marl.

There are thus shown to be 215 feet of beds of various kinds above the Red Marl, but it is difficult in the absence of unconformity to say where the Trias ends. Probably the 10 ft. of "greenish sandy clay" belongs to the Trias. Similar beds occur in the same position in the same locality. The geological age of the "white sand" and the "black sand" is "not proven," but probably they are Cretaceous, though there is no visible unconformity to show it. The "variegated marly clay" is certainly Cretaceous, as proved by the fossils quoted above.



1. Red Marl.
2. Greenish Sandy Clay.
3. Black Sand.
4. Dark grey marl and black clay.
5. Yellow Sand.
6. Grey Sand.
7. Cherty Greensand.
8. Clay, with chert.

* The place where the fossils were found.

V.—On the Application of the term Neocomian.

By A. J. Jukes-Browne, B.A., F.G.S.

Much confusion and difference of opinion appears to exist with regard to the classification and nomenclature of the strata which form the lower part of the Cretaceous system, and the chief element of this uncertainty and confusion is the misconception which prevails respecting the proper signification and application of the term Neocomian. The object of the present paper is to explain the continental usage of this name, and by showing its inapplicability to any of our English strata, to prepare the way for a more satisfactory grouping of our Cretaceous rocks.

For many years English geologists were content with the nomenclature employed by the earlier students of the Cretaceous system—Webster, Murchison, Mantell and Fitton. In 1864, however, the French term Neocomian was introduced by Prof. Judd,[1] who adopted it for the Cretaceous portion of the Speeton Clay, and Sir Charles Lyell subsequently used it as a synonym for the whole Lower Cretaceous series in England as distinct from the Upper Cretaceous series or the beds lying above the Lower Greensand. Consequently in many text-books we find the following arrangement of the Cretaceous groups:—

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[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 218.

	Southern Area.	*Northern Area.*
Upper Cretaceous.	Chalk	White Chalk.
	Upper Greensand Gault	Red Chalk.
Neocomian or Lower Cretaceous	Lower Greensand	Upper Neocomian.
		Middle Neocomian.
	Wealden	Lower Neocomian.

Now in order to ascertain whether this use of the name Neocomian was in any way desirable or justifiable, it is necessary to make some inquiry into the history of the name and its usual acceptation by the majority of geologists on the continent.

The primary groups or divisions of the Lower Cretaceous series usually recognized in France and Switzerland are those proposed by D'Orbigny, namely:—(1) *Neocomien*; (2) *Urgonien*; and (3) *Aptien*, and the history of these names is as follows. Previous to 1835 the rocks included in the first two groups were known as the "Jura-Cretacée" group, and in that year Thurman proposed to call them Neocomien, from their development in the neighbourhood of Neuchatel; this name was adopted by Marcou and others, but it is important to remember that this Neocomien series did not include the beds now known as Aptien; thus we find Prof. Marcou in his "Lettres sur les roches du Jura" writing in 1856 of Lower, Middle, and Upper Neocomien, but the summit of his Upper stage is the white limestone of Neuchatel (Urgonien).

Meantime D'Orbigny had been making his palæontological investigations, and had in 1843 described a series of beds lying between the Gault and what was then called "Neocomian" in the south-east of France; these beds he proposed to call *Aptien* from Apt in Vaucluse. The relation of the Neocomian as understood by Thurman and Marcou to the Aptien and Lower Greensand is clearly stated by Marcou in his first letter on the rocks of the Jura (p. 14) thus, "It is clear in fact that the Lower Greensand of England is in no way the equivalent of the Neocomian, and is hardly perhaps to be correlated with the upper part of the Neocomian . . . The blue marls which I have called the Marnes d'Hauterive, and which contain so many fossils, the Calcaire jaune inferieur, etc., that is to say, the Lower and Middle Neocomian, have no marine representatives in England."

He appends a table showing that these Neocomian strata are the marine representatives of the English Wealden, with possibly the lowest beds of the Lower Greensand, and he recommends the adoption of the name as indicating the normal marine type to which the freshwater Wealden is an exception.

Marcou, however, does not look with favour upon D'Orbigny's name of *Urgonien*, which was proposed in 1850, D'Orbigny then suggesting a new classification for the whole series, separating the upper half of the beds called Neocomian by Marcou under the name of *Urgonien* (from Orgon, Bouches des Rhone), and thus limiting the name Neocomian to the lower half of Marcou's series, that is, from the horizon of the yellow stone of Neuchatel downwards.

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Lastly, in 1854, Prof. Renevier, of Lausanne, described certain beds, which had previously been called Lower Aptien, as a separate subdivision under the name of Rhodanien, and in 1856 he published a brief note "On some points in the Geology of England," in which he announced the results of a visit he had made to England for the purpose of comparing the Swiss and English beds. The results are that the Lower Greensand is not the equivalent of the Neocomian, but corresponds exactly with the Aptien, and that the fauna of the Atherfield beds of the Isle of Wight has the strongest analogy with that of these Lower Aptien or Rhodanien beds. Marcou, writing in 1858, says that he willingly adopts these conclusions and opinions of M. Renevier.[1]

Meanwhile, a further modification had been proposed by MM. Coquand and Leymerie, who found a difficulty in separating the Urgonien and Aptien groups in the Pyrenean district, where according to their account the rocks contain a mixture of the fossils which elsewhere occur in the Urgonien and Aptien; they therefore proposed to combine these two groups, calling the division thus formed the Urgo-Aptien, and admitting a Neocomian division below. This suggestion has been adopted by Prof. Renevier, who published the following arrangement in 1874 (Tableau des Terrains Sedimentaires):

Urgo-Aptien	Aptien Rhodanien Urgonien.
Neocomien	Hauterivien Valanginien.

The facts upon which this scheme is founded require confirmation, and the nomenclature proposed does not seem to have found much favour, D'Orbigny's names being still generally employed by French geologists.

Having now explained the origin of this nomenclature, I proceed to give the succession of the strata in question at some of the typical localities.

The most complete sections are to be found in the S.E. of France (Departments of Vaucluse, Drome and Isere), where the succession is as follows, according to MM. Cornuel and Lory.

Aptien.	Greenish sandstones. Marls with *Belemnites semicanaliculus*, *Ammonites nisus*, *Martini* and *fissicostatus*. Marls with *Orbitolites* and other fossils.
Urgonien.	Limestone with *Caprotina* (Requienia) *Lonsdalei*. Marls with *Orbitolites* and *Heteraster oblongus*. Limestone with *Caprotina* (Requienia) *ammonia*.
Neocomien.	Marls with *Toxaster complanatus*. Marly limestones with *Ancyloceras Duvalii*. Glauconitic limestones with *Bel. dilatatus*. Red limestone with *Ostrea Couloni* and *Pygurus rostratus*. Limestone of Fontanil. Marls with *Bel. latus* and *Am. neocomiensis*. Argillaceous limestones with *Am. astierianus*. Limestones with *Terebratula diphyoides*.

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[1] Sur le Neocomien dans le Jura, Zurich, 1858, p. 63.

The basement beds are only found at and south of Chambery, while north of that place the Calcaire de Fontanil is the lowest bed, resting on Coral Rag. M. Lory remarks that all the limestones thicken northward toward Savoy and the Jura, while the marls increase to the southward, and Prof. Hébert [1] states that the argillaceous hydraulic limestones with *Ammonites Astierianus* attain a thickness of 500 mètres (1600 feet) near Chambery, the aggregate of the rest of the Neocomian above these limestones having an equal thickness, so that the total depth of this division here is at least 3300 feet. There is some doubt whether the lithographic limestones with *Ter. diphya* (*janitor*), which underlie those with *T. diphyoides*, should not also be classed as Neocomian. Renevier refers them to the Portlandian, but Hébert places them in the Neocomian (thickness 350 feet). Near Grenoble the Urgonien is said to be 900 mètres (nearly 3000 feet) thick, but nowhere else does it reach more than 1300 feet. The Aptien is about 60 feet thick at Grenoble, but at Bedoule it is as much as 650 feet, and in the Gard about 300 feet.[2] At Perte du Rhone, farther north, the section is given as follows by Prof. Renevier:—

Greensand with *Ammonites mammillaris*.

Aptien, 20 feet.	Hard greenish sandstone, with *Plicatula placunea* and *Am. Cornuelianus*.
	Sands without fossils.
	Greenish sandstone with *Ostrea aquila*.
Rhodanien, 56 feet.	Marly sandstones including a thin layer full of *Orbitolites lenticulata* (33 feet).
	Clays without fossils (10 feet).
	Marls with *Heteraster oblongus*, *Trigoniæ* and *Aporrhais Robinaldina*, etc.
	Red Limestone with *Heteraster oblongus*, *Pterocera pelagi*, and *Caprotina Lonsdalei*.
Urgonien, 340 feet.	White friable limestones and grey compact limestones in alternating beds, and containing *Caprotina* (*Requienia*) *ammonia*: base not seen.

By Pictet and Campiche the beds are differently grouped; they place the red limestone in the Urgonien, and class the overlying marls and clays as Lower Aptien, the Upper Aptien here being very thin. Sandy limestones with fossils of true Neocomian species occur at a lower horizon, the above section only extending as far as the confluence of the Rhone and Valserine.

In the Jura and near Neuchatel the succession is given as follows, the thicknesses of the lower beds being those given by Marcou:—

Aptien and Rhodanien.	Greensands of Presta with *Plicatula placunea*.
	Yellow marl with *Heteraster oblongus* and *Orbitolites*.
Urgonien, 150 feet.	White limestone with *Requienia ammonia*.
	Yellow limestone with *Goniopygus peltatus*.
Neocomien, 250 feet.	Yellow stone of Neuchatel.
	Marls of Hauterive with *Am. radiatus*.
	Limonite de Metabief with *Pygurus rostratus*.
	Limestone of Auberson with *Toxaster Campichei*.

[1] Bull. Soc. Geol. de France, ser. 2, vol. 28, p. 142.

[2] For this and other information I am indebted to Dr. Ch. Barrois.

The two lowest Neocomian groups have been termed by some *Valenginien* and the two upper *Hauterivien;* the lowest rests on beds of Purbeck age, containing *Planorbis Loryi*, and other freshwater shells.

Dr. Barrois informs me that the total thickness of the three divisions in the Jura is from 200 to 300 mètres (650 to 990 feet).

In the north of France there is only one locality where anything like a complete section of the series is found, and this is at Vassy in the north-eastern department of Haute-Marne. The succession here as described by M. Cornuel is as follows:—

Greensand with *Ostrea arduennensis* (? base of Gault), 28 feet.

Aptien. 97 feet.	Sand and Sandstone with *Ostrea aquila* and *O. arduennensis.*
	Plicatula clays—in three divisions, the middle containing *Ammonites nisus* and *fissicostatus*, the lower *Ostrea aquila* and *Ter. sella*, besides *Plicatula placunea.*
	Red marl with *Orbitolites lenticulata*, *Heteraster oblongus* and other fossils.
Urgonien, 118 feet.	Oolitic ironstone and ferruginous sandstone, with *Unio* and freshwater fossils.
	Mottled clays and sands (freshwater).
	Clay with *Ostrea Leymerii.*
Neocomien, 34 feet.	Yellow marly clay.
	Spatangus limestone (*Tvxaster*, etc.)
	White sand.
	Ferruginous sands and ironstone.
	Dark marly clay.

Prof. Hébert prefers to group the Oyster-clay as Neocomien, and to place the red marl at the top of the Urgonien, commencing the Aptien with the Plicatula-clays.

In passing westward from the Haute Marne, the Neocomien and Urgonien beds appear to thin-out, and are overlapped by the Aptien, which in Ardennes is reduced to a few feet of glauconitic clay with marly ironstone at the base containing fossils and pebbles derived from Palæozoic rocks like the "pebble beds" of Godalming and Faringdon (Barrois, Terr. Cret. des Ardennes, pp. 252, 263).

It is interesting to notice that in the Vassy section the marine Neocomian beds are succeeded by a group the greater part of which consists of freshwater beds resembling our Wealden strata. Moreover, the fauna of the overlying red bed has been identified by Renevier as that of his Rhodanien, and he finds the same fossils in the Atherfield beds of the Isle of Wight; here therefore we seem to have a basis of correlation, and it becomes important to decide whether this Rhodanien horizon should be grouped with the Urgonien or the Aptien, for it is nowhere of sufficient stratigraphical importance to rank as a separate primary division.

Two of the best modern authorities on the Cretaceous rocks of France, namely, Prof. Hébert and Dr. Ch. Barrois, agree in placing the "couche rouge de Vassy" in the Urgonien, but the difference of opinion which exists on this point may be held to prove that the Rhodanien is really a passage group, and that no very decided line can be drawn between the Aptien and Urgonien divisions of the continental series.

It is now time to examine the succession exhibited in our southern counties, where, as is well known, the series consists of a thick mass of freshwater strata (Wealden beds), overlain by marine clays and sands which are known under the name of Lower Greensand. These marine beds are everywhere divisible into three stages, the fossils of which are to a certain degree different. In the Wealden area there are:—

3. Folkestone and Sandgate beds, with *Rhynchonella Gibbsii*, *Rh. sulcata*, *Thetis Sowerbyi*, *Corbula elegans*, etc. (150 feet).

2. Hythe beds, with *Plicatula placunea*, *Exogyra sinuata*, *Ammonites Martini*, *Am. furcatus*, *Ancyloceras gigas*, *A. Hillsii* (200 feet).

1. Atherfield Clay, with *Trigonia caudata*, *Tr. dædalea*, *Perna Mulleti*, *Holocystis elegans*, etc. (90 feet).

In the Isle of Wight the corresponding series is very much thicker, but may be divided as below:—

3. Shanklin Sand, sands and clays down to the sand with ferruginous concretions (256 feet).

2. Walpen Sands and Crioceras beds, with *Am. Martini*, *Ancyloceras gigas*, *An. Hillsii*, *Exogyra sinuata*, and *Ter. sella* (400 feet).

1. Atherfield Beds, with *Trigonia caudata*, *T. dædalea*, *Perna Mulleti*, *Corbis corrugata*, and *Aporrhais Robinaldina* (150 feet).

Now as the Atherfield Clay is certainly not older than the Rhodanien of Renevier, there can be little doubt that the two higher groups form an expanded equivalent of the French and Swiss Aptien. The Urgonian facies of the Atherfield fauna was recognized long ago by M. Cornuel, but he remarks in 1874 that "no clear separation between the Neocomien (*i.e.* Urgonien) and Aptien can be traced in the Isle of Wight, on account of the mixed assemblage that occurs in the Crackers, which form a passage from one to the other."[1] It is evident therefore that here, as in the south of France, there is a complete passage between the representatives of the Urgonien and the Aptien.

It is only necessary to add that the lower marine beds have a limited extension, and that the uppermost beds (Shanklin sands) overlap them and spread northward over the Jurassic rocks, all the so-called Lower Greensand of our midland counties belonging to this group, the range of which is probably continuous beneath the Gault as far as Norfolk, where they pass into the upper beds of the northern Cretaceous area.

In Lincolnshire and Yorkshire beds older than the Aptien once more make their appearance, and in this area we appear to have a much more complete marine series than that of the southern counties. The Yorkshire succession has been well described by Prof. Judd some twenty years ago, and descriptions of the Lincolnshire beds will shortly appear in the Memoirs of the Geological Survey. The grouping adopted by Prof. Judd, however, does not appear to be entirely satisfactory, and his correlations with Neocomien, Urgonien, and Aptien have not been accepted by French authorities, so that I feel justified in subjecting them to some slight criticism. First, therefore, as to the grouping of the zones; there does not seem any very good reason why the zone of *Ammonites speetonensis* should be classed with the lower zones rather than with the middle group. Prof. Judd identified twenty-six species from this zone, and of these only eight occur in the zone of *Am. noricus*, while thirteen species (50 per cent.) range up into the *Pecten cinctus* beds: again in Lincolnshire the only determinable Ammonites obtained from the clays overlying the Tealby ironstones with *Pecten cinctus* were the varieties of *Am. speetonensis* (*concinnus* and *venustus*). I am inclined, therefore, to think that a part at any rate of Prof. Judd's *speetonensis* zone should be grouped with his Middle division rather than with the Lower. The *noricus* zone does not appear to have any equivalent in Lincolnshire, and it is quite possible that the masses of clay which form the *noricus* and *speetonensis* zones in Yorkshire did not extend into Lincolnshire, no contemporaneous deposits being formed in the latter area.

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[1] Bull. Soc. Geol. de France, 1874, p. 390.

In the next place it does not appear to me so very clear that the fauna of the Upper division has a closer analogy with that of the Atherfield Clay than that of the Middle division has. There is no very marked correspondence between any part of the northern and southern series, the areas in which they were deposited were evidently to a great extent separated from one another, many species common in the one area do not occur in the other, and the time range of some of those species which do occur in both series appears to be different, thus *Perna Mulleti* is abundant in the Atherfield Clay of the south, while in Yorkshire it is only quoted from the Upper division. It occurs, however, in the middle clays of Donington in Lincolnshire, and it is these clays both in Yorkshire that I am inclined to regard as the homotaxial equivalents of the Atherfield Beds, the abundance of *Meyeria* (though the species are different) and of *Exogyra sinuata* are features in common.

If these views be accepted, the Yorkshire and Lincolnshire series can be brought into greater harmony, and both may be correlated with the southern type as follows:—

	Yorkshire.	*Lincolnshire.*	*Isle of Wight.*
150 feet	Clays without fossils Cement beds	Carstone? absent?	Shanklin Sands.
250 feet	Pecten cinctus beds Ancyloceras beds	Donington Clay and Tealby Beds	Walpen Sands, etc. Atherfield Clay.
	Speetonensis zone	Wanting . . .	Part of the Wealden Beds.
100 feet	Zone of Am. noricus		
	Zone of Am. Astierianus	Spilsby Sands	
		Unconformity	— Hastings Sands.

This view finds support in the opinion expressed by M. Coquand,[1] that the only part of the Speeton Clay series which can be correlated with the Neocomien of the south of France is the zone of *Am. astierianus*, and that all above it must be referred to the Urgonien and Aptien divisions. The zone of *Am. astierianus* is acknowledged by all authorities to be homotaxial with the Hauterivien marls and Spatangus limestones, and the oldest Neocomian rocks which underlie these are not therefore represented in the Yorkshire area. I see no reason however why the zone of *Am. noricus* should be excluded from the Neocomian, since that Ammonite is probably only a variety of *Am. neocomiensis.*

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[1] Bull. Soc. Geol. de France, 2nd ser. vol. 26, p. 211.

Coming now to the question of general nomenclature, I cannot but think that Prof. Judd's proposal to apply the name Neocomian to the whole Lower Cretaceous series was a very unfortunate one. It would appear that at the time of writing his paper on the Speeton Clay, Prof. Judd was under the impression that this series had a claim to be regarded as a distinct system, both on stratigraphical and palæontological grounds;[1] now if subsequent investigation had confirmed this belief, and had led to the establishment of a Neocomian system distinct from the Cretaceous system, but of equal palæontological importance with the other systems which are recognized in geology, no objection could now be taken. But this is not the case: the thickness of the Neocomien, Urgonien, and Aptien rocks in the south of France appears to be very great (from 1000 to 6000 feet), but the mere thickness of a group of strata does not justify the creation of a new system unless they contain a sufficiently distinct assemblage of fossils, and in this case the fauna is neither so large and varied or so peculiar as to entitle them to be separated from the Cretaceous system: they are regarded by all who have studied them as forming the lower portion of this system, just as the Gault and Chalk form the upper portion of it, and their separation would be no more justifiable than that of the Lias from the Jurassic system.

This being so, the proposal to call the lower series Neocomian ceases to be logically defensible, unless a new name is found either for the Upper Cretaceous series or for the whole system which includes both. Prof. Judd's nomenclature, with the belief he then entertained, was a logical one, but I must maintain that the manner in which it has been subsequently employed is entirely illogical. There is an inclination in certain quarters to adopt the name Neocomian for the lower division, and to limit the application of Cretaceous to the upper division; this plan would certainly secure logical uniformity, but those who suggest it are bound to propose a new name for the system which includes these two divisions, otherwise it would only "make confusion worse confounded." There is really no necessity for any such innovation, or for any alteration of the general scheme of nomenclature to which we are accustomed. The Cambrian and the Carboniferous systems are simply divided into lower and upper series, why therefore should we not be content to treat the Cretaceous system in the same way, and to speak simply of Lower and Upper Cretaceous series?

Further, it must be remembered that the majority of French and Swiss geologists use the term Neocomian in its special application as limited by D'Orbigny, and its employment in any other sense, except on the strongest grounds of expediency, is therefore to be deprecated. I am fully aware that Prof. Hébert is one of those who has adopted Prof. Judd's nomenclature, but Prof. Hébert appears to shrink from proposing a new name for the Lower (Neocomian) beds, though he employs D'Orbigny's names for the other groups; consequently he has only succeeded in introducing an element of confusion which did not previously exist in the French nomenclature.

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[1] See Quart. Journ. Geol. Soc. vol. xxiv. p. 228.

The height of incongruity is reached when, by retaining the name of Wealden for the fresh-water beds and adopting that of Neocomian for all our marine beds, we have a Neocomian overlying the Wealden! and consequently applied to the very beds Marcou and Renevier have so clearly and carefully distinguished from those strata which were originally called Neocomian in Switzerland and the south of France (see ante). I trust that I have now made it clear that to continue the use of *Neocomian*, either as a synonym for Lower Cretaceous or as a substitute for Lower Greensand, would be productive of immense confusion, and would entirely stultify the work of two of the principal authorities upon the beds in question. Neither does it seem desirable to introduce the term *Aptien* into British nomenclature, partly because of the difference of opinion which exists in France as to the relative extension of Aptien and Urgonien, and partly because there is not sufficient continuity between the French and English areas to make any correlation so safe and certain as it is in the case of the Upper Cretaceous groups. The Cretaceous rocks of England are now undergoing revision by the members of the Geological Survey, and the desirability of formulating a new nomenclature will be considered when the work is farther advanced: the merits of the name (*Vectian*) which I have already proposed as a substitute for Lower Greensand will then be discussed; at present I am content to let it remain in abeyance. For my present purpose the local names used for the groups in the Wealden area will serve as a means of comparing the beds of southern England with those of northern and southern France so far as is possible under the circumstances; this is done in the following table:—

South England.	*N.E. France.*	*S.E. France.*	
Folkestone and Sandgate Beds.	Sands and Sandstones.	Aptien	
Hythe Beds.	Plicatula Clays.		
Atherfield Clay.	The red band.	Rhodanien.	
Weald Clay.	Freshwater Beds.	Urgonien.	
	The Oyster Clays.		
	Yellow Marl.	Upper	Neocomien.
	Spatangus Limestone Sands and Clay.		
Hastings Sands.	(Absent).	Lower	

[illegible]

VI.—On the Sequence and Systematic Position of the Cambrian Rocks of Nuneaton.

By Prof. C. Lapworth, LL.D., F.G.S.

In the Geological Magazine for December, 1882,[1] I published a brief note upon the "Discovery of Cambrian Rocks in the

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[1] Lapworth, Geol. Mag. 1882, Dec. II. Vol. IX. p. 563.

Neighbourhood of Birmingham," in which evidences were adduced demonstrative of the fact that the oldest sedimentary strata of the Lickey Hills, and of the neighbourhood of the town of Nuneaton, previously referred to the Llandovery and Carboniferous respectively, are, in reality, of Cambrian age. Since that date these Cambrian areas have been in part mapped by the members of the Field Geology Class of the Mason College, and many confirmatory and interesting points of detail have been detected by myself and others. Some of these will be found incorporated in Mr. Jerome Harrison's valuable paper on the "Pre-Carboniferous Floor of the Midlands," published in the Midland Naturalist for 1885.[1] My friend Mr. T. H. Waller, B.Sc., kindly undertook the microscopical examination of the igneous rocks associated with these Cambrian strata, but the results of his observations are as yet unpublished. I hope to treat of the subject as a whole at the forthcoming Meeting of the British Association, but as I have recently had to prepare a general account of the Cambrian rocks of the Midlands for the local "Association Guide Book," I have thought that a summary of my conclusions as there laid down respecting the main fossiliferous area of Nuneaton may be of present interest to other geologists working among these rocks, and may serve as a point of departure for further discussion and investigation.

The largest area of Cambrian rocks in the Midlands is that of Nuneaton and Atherstone in Eastern Warwickshire. It extends from the neighbourhood of Bedworth on the south to a point beyond Merivale Park near Atherstone on the north, a distance of about eight miles, and has a maximum width to the north of the hamlet of Oldbury of about a mile and a quarter. On the eastern margin of the Cambrian area its beds are overlain unconformably by the basement beds of the Keuper Sandstone, around and to the south of the town of Nuneaton. To the north of that town they are generally faulted against the Keuper Marl, but are locally overlapped by some of its basal beds. On the western side the Cambrian rocks are overlain unconformably by the lowest sandstones of the East Warwickshire Coalfield, but there appear evidences of faulting between the two systems in some localities.

The sequence of the rocks of this Cambrian area is as follows:—

A. *Caldecote Volcanic Rocks.*

(1) A thin series of volcanic ashes, beautifully stratified, shown in an old cutting (The Tunnel) a few yards to the north-west of Caldecote Lodge, and forming the lowest rocks exposed in the Nuneaton district.

(2) Quartz-felsite and diabase-porphyrite, seen in an old quarry about a quarter of a mile south-east of Caldecote Lodge. The quartz-felsite is often brecciated in character, and is doubtfully intrusive in the Caldecote ashes. The diabase-porphyrite is subsequent in age to the quartz-felsite, resting upon it, making its way into it in veins and strings, and including fragments of the quartz-felsite caught up in its flow.

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[1] Harrison, Midland Naturalist, 1885, vol. viii. pp. 38—69 *et seq.*

B. *Hartshill Quartzite.*—Thick-bedded quartzite, with intercalations of sandy shales. This formation extends from Tuttle Hill to Hartshill, and is exposed in many large quarries. The basement beds of the quartzite contain abundant fragments of the Caldecote volcanic rocks. At Mr. Boon's quarry, between Caldecote Lodge and Tuttle Hill, its lowest zone is laid bare, and is almost wholly made up of this derived volcanic material.

Along a straight line ranging from the Midland Railway Station at Nuneaton to the village of Hartshill, near Atherstone, the highest zone of the quartzite is succeeded by the

C. *Stockingford Shales.*—A thick group of purple, green, grey and black thin-bedded shales, which are separable into two main divisions :—

(1) *Purple and Green Shales* (*Obolella Beds*).

The lowest zones of this division are stained of a deep purple colour, and were formerly worked for manganese. Higher up the purple shales pass up into green and grey beds, but the red beds re-appear at intervals to the summit of the division. At Marston Jabet, Camp Hill, and in many localities beyond Hartshill, fossils occur, which are, however, limited to very thin seams. The commonest forms may be provisionally referred to:—

Lingulella pygmæa, Salter.	*Protospongia fenestrata*, Hicks.
Obolella sagittalis, Salter.	*Acrotreta socialis*, Von Seebach.
Orthis lenticularis, Dalm.	*Obolella Salteri*, Holl.

(2) *Gray shales with bands of intensely black carbonaceous shales* (*Agnostus Beds*).

These are divisible into two main zones :—

(a) *Zone of Agnostus sociale*, Tullberg.

The characteristic fossil of this band is the well-marked variety of *Agnostus pisiformis* (Linn.), which gives its name to the zone. It has been met with in these beds at Chilvers Coton, Stockingford Cutting, and Oldbury Reservoir.

Another very characteristic fossil in the band is *Beyrichia Angelini*, Barr., a well-known Swedish species. Its associated forms are a species of *Lingulella*, apparently identical with *Lingulella Nicholsoni*, Callaway, and a species of *Obolella*.

(b) *Zone of Sphærophthalmus alatus*, Beck. (?= *Zone of Peltura scarabeoides*, Wahlenberg).

The characteristic fossil of this zone is the well-known Scandinavian species *S. alatus* (*S. humilis*, Phill.), already known from the British Upper Cambrian rocks of North Wales and the Malvern Hills.

It is associated with abundant specimens of an Obolella of the type *Obolella sagittalis*, Salt., but with strongly-marked concentric lines of growth (var. *concentricus*). Species of *Agnostidæ* occur more rarely, together with carbonaceous remains resembling the *Hymenocaris vermicauda* of Salter, etc.

The examples of *Sphærophthalmus* are locally abundant but poorly preserved, head, body-rings, and free cheeks. They are confined, as in the Malverns, to a single seam which is very difficult of detection.

This zone is the highest band of the Cambrian visible in the Nuneaton District, occurring immediately to the east of the unconformably overlying Carboniferous. Fossils have been obtained from it in the quarries to the south-west of Merivale Park, and in the Stockingford railway cutting.

No recognizable fossils have been met with in the Hartshill quartzite, but those enumerated above from the various zones of the Stockingford shales allow us to assign the Cambrian rocks of Nuneaton to their approximate position in the general succession of Cambrian deposits. These Stockingford shales fall apparently into the same systematic position as the well-known Upper Cambrian shales of the Malvern Hills—representing the grey and black shales which there lie between the *Hollybush Sandstone* below and the *Dictyonema* bed above. *Lingula pygmea* and *Obolella Salteri* occur in the lowest shale zones of the Malvern Hills, *Sphærophthalmus alatus* and *Agnostus pisiformis* are among the characteristic fossils of the black shales above. In other words, the Stockingford beds come into the place of a part of the Lingula Flags of North Wales—possibly ranging to the Upper Dolgelly. With the Scandinavian succession the agreement is even closer; the zones of *Agnostus sociale, Beyrichia Angelini* and *Sphærophthalmus alatus* (= zone of *P. scarabeoides*) occurring in the same order in the Midlands, in Scania and in Norway.

Although the underlying Caldecote Volcanic Group has distinctly afforded the material of which the basement bed of the Hartshill Quartzite is composed, it is doubtful if the systematic break between the Caldecote and Hartshill formations is of great moment. The Caldecote ashes have the same general strike and amount of inclination as the overlying quartzite, and are equally unmetamorphosed.

Both the Stockingford Shales and the Hartshill Quartzite are pierced by intrusive dykes of Pre-Carboniferous diorite. This rock has been already described by Mr. Allport, F.G.S., in a memoir which has become classic in the history of British Petrography.

A preliminary notice of the petrographical characters of the Caldecote igneous rocks by Mr. Waller will be found in the paper which follows the present communication.

VII.—PRELIMINARY NOTE ON THE VOLCANIC AND ASSOCIATED ROCKS OF THE NEIGHBOURHOOD OF NUNEATON.

By THOS. H. WALLER, B.A., B.Sc.

THE relations of the various rocks of the district lying to the North and South of Nuneaton have already been discussed by Prof. Lapworth from the data afforded by investigation in the field. He put into my hands many specimens of the different rocks for the purpose of microscopical examination. I have also received specimens from Mr. W. J. Harrison, and have collected some myself. Mr. J. J. H. Teall has also placed at my disposal a number of slides which he has had prepared from material of his own collecting.

From these I have prepared a considerable number of thin sections, and I propose to give here a summary of the chief conclusions at which I have arrived as to the following rocks:—

1. The Ashes.
2. The Quartz-Felsite.
3. The Basic rock which is seen in contact with the Quartz-Felsite.
4. The Quartzite.
5. The Diorite in the latter.

1. *The Ashes* from the "Tunnel" at Caldecote are distinctly bedded, and contain, where they are coarsest, angular grains of quartz and felspar; but in most parts the dust has originally been so fine, and subsequent changes have so much veiled the components, that not much can be made out as to their constitution. A light-coloured specimen from this locality has an appearance and texture very similar to those of a tuff from the Pentland Hills, of which I possess a specimen. It contains a number of rather darker grains, which are not evenly distributed all over, but are gathered up into a sort of network with irregular meshes, the open spaces being nearly free from them.

A few of the felspar grains are much larger than the majority of the fragments of which the rock is made up; one well-defined and pretty perfect crystal measuring about $\frac{1}{20}$ of an inch, another of orthoclase measures $\frac{1}{100}$ of an inch. There are occasional fragments of apparently a fine-grained basalt, and in some of these large felspar crystals are included, showing that the basalt was porphyritic. I have seen no well-defined augite, but a few green patches give rather the impression of an altered pyroxene. The quartz fragments are not very frequent, and the general character of the mass is decidedly basic.

In the coarse conglomerate at the base of the quartzite, blocks of ash are found, and those which I have examined are made up of much larger fragments than the specimens from the Tunnel. The fragments present a considerable variety of aspect; a few of them look like pieces of a very vesicular lava—basic apparently: others are pale green, like some of the Welsh felsites of the Snowdon district, and have the peculiar curdled or damascened appearance which has been often described in these.

2. *The Quartz-Felsite.*—It is only sparingly that specimens occur which have the appearance of typical unaltered quartz-felsites. In them the quartz and felspar occur in large grains and crystals, the ground-mass forming as usual inclusions and indentations in the former. In the ground-mass itself the fluidal texture is very marked, and it shows the usual indeterminate polarization of the felsites.

The felspar is much clouded by products of decomposition, but there is a good deal left which allows the twinning to be made out. Both orthoclase and plagioclase occur; in the latter, frequently with very fine and sharply-distinguished lamellæ.

The greater number of specimens which have a general look of quartz-felsite, seem to me to have much more of the character of a felsite brecciated and recemented with probably but little disturbance.

The quartz grains, instead of having mostly rounded outlines, are in very large proportion angular, and have a very fragmentary look. The felspar grains, on the contrary, are very frequently rounded, and the whole of the crystalline constituents are packed closely together; touching, in the majority of cases, as if they had been loose grains. This peculiarity of aspect naturally varies in different specimens, and in one or two I think I have detected a quartz grain in the act of breaking up. It is of irregular shape, and at one side is covered over with a network of strings of minute fluid cavities, which divide it into roughly polygonal portions; as we pass to the other side of the crystal, however, these become lines of an infiltrated green mineral, and at the extreme edge a few of the polygonal fragments are quite detached, and separated from the main mass by portions of the ill-defined ground-mass which occurs in this particular specimen. Here the alternative lies between considering the fluid cavities as the remaining indications of cracks which originally divided the crystal, or looking upon the strings of cavities as original, and as giving direction to the separation by being planes of weakness. It is rather in favour of the former assumption that the reticulated arrangement of the cavities is, so far as my observation goes, more frequent in the specimens which have the greatest appearance of disturbance. Where the crystalline grains of quartz are indented with intrusions of the ground-mass, there is very frequently a line of cavities following the outline of the indentation. One specimen shows very well the care needful in deciding that an apparent inclusion is not in connection with the exterior. A quartz grain has a row of four roundish apparent inclusions. The plane of the section, however, has fallen *just* within the neck connecting one of these included masses with a little indentation of the margin, so that there is a very faintly visible cloud observable showing the actual connection.

In various places in this rock there are green patches and a few black and brown ones. These are not so sharply defined microscopically as they appear in hand-specimens. In some cases they seem to have their margins indented with a quartz grain, or to inclose a bit of felspar; but occasionally they seem quite free from any but microscopic crystals. The black patches, so far as I have examined them, have the look of green serpentinous alteration products, and some of the browner ones have much the appearance of the neighbouring fine ashes, but others seem more filled with minute lath-shaped crystals, which have much of the character of felspar microliths.

3. *The Dark Basic Rock* which is in contact with the quartz-felsite in one little disused quarry has undergone great alteration—in some parts to the complete obliteration of any original structure, in others the components are very fairly preserved. Close to the junction with the quartz-felsite, and running into it in strings and tongues, the appearances strongly suggest a rock originally glassy, which has been subsequently devitrified, like the glassy base of many felsites. In some specimens the structure is markedly porphyritic; felspar crystals of considerable size occurring in a ground of crystals

apparently of felspar of very small dimensions. In others the crystals of felspar are larger and of more uniform size. Extremely little augite has escaped, but it is curious that those which are preserved show, in addition to the twinning with the orthopinacoid as the plane of composition, which is common, the unusual cleavage parallel with the basal plane described by Mr. Teall as occurring in the prevailing pyroxene of the Whin Sill of the North of England. One section approximately in the plane of the clinopinacoid shows the cleavages forming obtuse angles meeting in the plane of composition; the angles were measured as 66° on one side, and 65° on the other, and the extinctions 40° and 41° from the dividing line. Where the colour of the augite can still be seen, it is very pale.

The larger porphyritically-developed felspars give extinction angles such as indicate one of the more basic plagioclases, probably labradorite. Some yellowish hornblende and a green chloritic or serpentinous mineral are apparently products of alteration.

The manner in which this rock, which seems to agree in characters with Rosenbusch's diabase porphyrite, runs in among the quartz and felspar grains of the quartz-felsite previously mentioned, the presence of detached angular quartz grains in its mass, and the appearance of flow which it has, lead me to believe that it flowed as a lava over a broken disintegrated surface of quartz-felsite or of a bed of sand derived from it.

4. *The Quartzite.*—The quartz sand which has formed the foundation of the quartzite shows in some of the lower beds its derivation from such a rock as the quartz-felsite previously described, by the survival of canals and inclosures of the felsitic ground-mass, and indeed, in the conglomerate, quite at the base, little pebbles of felsite occur along with angular fragments of the fine ashes. In the normal quartzite the grains of primary quartz are well rounded, and contain in many cases a great number of minute fluid cavities. The secondary cementing quartz is much more free from cavities or inclusions of any sort. It is an optical continuity with the primary quartz, so that in polarized light the impression is given of polygonal areas of colour. The appearance is markedly different where, as is quite frequently the case, a grain of felspar, or of felsite, or of the ashes, occurs. On these no quartz is deposited, but they are simply enveloped in that which has crystallized on adjoining grains.

5. *The Diorites* which occur in the quartzite are in an advanced state of alteration, and often not much more than the shapes of the old crystal forms can be made out. Calcite is developed in them to a considerable extent.

In a specimen from Tuttle Hill, collected by Mr. Teall, and kindly lent to me by him, the hornblende is in the form of long and comparatively slender crystals, with frequent cross-divisions. A similar structure occurs in a specimen from Merivale Church, kindly given to me by Mr. W. J. Harrison.

REVIEWS.

I.—Dr. Max Schlosser on the Ungulata.[1]

THE author of this memoir, which aims at giving a complete pedigree of all the Perissodactyla and Artiodactyla, is to be congratulated on the amount of information he has brought together, and the strong thought characterizing the whole of it. The pedigrees are indeed given as though they were certain, but we have no doubt that the author himself would admit that they must be regarded as indications only of the way in which the line of evolution may have advanced, rather than the absolute line itself. The author's American experiences render his observations as to the probable identity of many American and European genera of especial value.

The Condylarthra the author regards as the primitive stock from which both the Perissodactyla and Artiodactyla have originated, and points to *Phenacodus* as being very closely allied to *Hyracotherium.* Instead of the nine or ten families into which the Perissodactyla are usually divided, Dr. Schlosser proposes to reduce the number to four. Thus the Lophiodontidæ gives its type genus to the Tapiridæ, while *Hyracotherium* and its allies, together with the Palæotheriidæ, are included in the Equidæ. That there is very much to be said in favour of the inclusion of the Palæotheriidæ in the latter is perfectly true, since the division between them is but an arbitrary one; and there is an equal transition from the Palæotheriidæ through *Pachynolophus* to *Hyracotherium.* It seems, however, hardly consonant with the usual acceptation of the term to include in one family such widely different forms as *Hyracotherium* and *Equus,* even although the one be the ancestor of the other; and the total separation of the former from *Lophiodon,* to which it seems to us to be more nearly allied than is that genus to *Tapirus,* appears decidedly inadvisable. Dr. Schlosser appears, indeed, to think it necessary that all the members of one line of evolution must be included in a single family; but we would point out to him that since he admits the descent of the *suborder* Perissodactyla from the *suborder* Condylarthra, there is no objection against adopting the same view in the case of *families,* and regarding the Equidæ as descended from the Palæotheriidæ, and the latter from the Lophiodontidæ, which may have also given rise to other groups. The Chalicotheriidæ forms the third family, which is taken to include both the Mesodontidæ and Macraucheniidæ; and we confess we should like more conclusive evidence in favour of this view, as the dentition of the latter appears to indicate affinity with *Palæotherium.* The Rhinocerotidæ includes the true Rhinoceroses, *Hyrachyus* and *Elasmotherium.*

We may here be permitted to express some surprise that while the author so reduces the number of families, he follows the example of Gray in retaining a vast number of genera; and we regret (even if it be only on the lowly ground of pity to the power of memory of average mortals) that he did not follow the excellent example of

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[1] "Beiträge zur Kenntniss der Stammesgeschichte der Hufthier, etc.," Morphol. Jahrbuch, vol. xii. pp. 1-136, pls. i.-vi. (1886).

Prof. Flower in including all the recent Rhinoceroses and most of the fossil ones in a single genus, as well as in uniting *Paloplotherium* with *Palæotherium*. We are glad to see the identity admitted of *Orohippus* with *Hyracotherium*, and the suggestion that *Eohippus* may also be the same; but we are surprised at the retention of *Pliolophus* (with which *Orotherium* is coupled) as distinct from *Hyracotherium*. *Mesohippus* and *Miohippus* are rightly shown to be indistinguishable from *Anchitherium*, and *Protohippus* from *Hipparion*. Some confusion appears to exist in the author's mind with regard to *Pachynolophus*, since he separates it widely from the so-called *Propalæotherium*, which Gaudry has shown to be identical. The confusion may be in part accounted for by the retention in *Hyracotherium* of the so-called *H. siderolithicus*, which is really a *Pachynolophus;* but it is difficult to understand what forms Dr. Schlosser regards as the representatives of the latter genus. The genus *Tapirulus*, which has been very generally regarded as an Anoplotheroid, is referred to the Tapiridæ, but we could wish for stronger evidence on the point.

In the Artiodactyla the same "lumping" of families is observable. Thus the author proposes (1) the Anoplotheriidæ, (2) the Dichobunidæ, which is subdivided into the Dichobunidæ proper, the Cænotheriidæ, Xiphodontidæ, Tragulidæ, and Gelocidæ, (3) the Tylopoda, (4) the Oreodontidæ, (5) the Anthracotheriidæ, and (6) the Suidæ. We are not quite clear as to the author's views with regard to the Giraffidæ, Cervidæ, and Bovidæ (which is split into Bovidæ, Antilopidæ, and Ovidæ); but they are all regarded as descendants of the Gelocidæ, and it is apparently intended that they should be considered merely as subdivisions of that subfamily,—a view which will hardly commend itself to the English school of zoology. The comparatively wide separation of *Xiphodon* from *Anoplotherium* is in opposition to the view of Prof. Rütimeyer, which is based on the resemblance presented by the former to the undoubted Anoplotheroid genus *Dacrytherium;* and we are inclined to give more weight to the remarkable resemblance existing between the molar dentition of the three genera and the affinity of their general carpal and tarsal structure, than to the features of carpal and tarsal reductions respectively known as adaptive and inadaptive. *Xiphodon* does, however, undoubtedly show strong indications of affinity with the Cænotheriidæ and the Dichodontidæ (Gelocidæ), and thus indicates a transition from the Anoplotheriidæ to the Tragulidæ. The author adopts the recent view of not separating *Eurytherium* from *Anoplotherium*. *Lophiomeryx*, which was placed by Rütimeyer between *Dichodon* and *Gelocus*, is referred to the Tragulidæ, which also contains *Bachitherium; Lophiomeryx Gaudryi*, we regret to see, has been made the type of another new genus—*Cryptomeryx*. The Anthracotheriidæ are taken to include *Merycopotamus*, and also the bunodont *Elotherium* (*Entelodon*), which is classed by Prof. Flower together with *Cebochœrus* and *Chœropotamus* in the Chœropotamidæ. The Suidæ is taken to comprise the two latter genera, together with the Dicotylidæ, Phacochœridæ and Listriodontidæ, and the peculiar genus

Acotheridum, which, although presenting dental characters allied to *Cebochœrus*, yet in other respects is so like *Dichobunus* that it is difficult to think that it is not nearly allied. Both *Palæochœrus* and *Chœromerus* are retained as distinct from *Hyotherium*.

We venture to think that the plan of taking one very large family like the Dichobunidæ and subdividing it into several subfamilies (all of which have the same termination), and the apparent subdivision of one of these subfamilies into sub-subfamilies is not advisable, and is sure to lead to confusion;[1] and we should have thought it better to rank such subfamilies as families, since it is quite impossible to attempt to make all families or other divisions of precisely the same relative value. That the author himself has not succeeded in this we think is evident, when he sees reason to place *Anthracotherium* and *Chœropotamus* in juxtaposition, while *Cænotherium* and the closely allied *Dichobunus* are made the types of separate subfamilies; but this is still more glaringly the case if the Dichobunidæ is to include all the Pecora (as a subdivision of the Gelocidæ), and yet not to have higher rank than the Oreodontidæ.

It is, however, hardly to be expected that any two persons can entirely agree on such points, and in concluding this notice we beg to congratulate the learned writer on this decidedly valuable contribution to morphological zoology. R. LYDEKKER.

II.—DR. C. DEPÉRET ON THE PLIOCENE VERTEBRATA OF FRANCE.[2]

THIS memoir will be welcomed by all students of the Pliocene Mammalia of the South of France, as it throws much light on many of the forms imperfectly described many years ago by Croizet and Jobert, and Aymard. The work consists of three parts: 1st, a geological description of the Rouisillon basin; 2nd, a description of the Vertebrates; and, 3rd, a survey of the Pliocene Vertebrates of Europe. In the Pliocene the author includes all the strata from the Norfolk Forest-bed to the Montpellier and Casino beds, and follows the usual French view of classing the Pikermi and Mont Lebéron beds with the Upper Miocene instead of at the base of the Pliocene.[3]

The only new species of Mammal described is *Viverra Pepraxti*, which appears intermediate between *V. civetta* and *Ictitherium*; but there are several interesting forms which may be briefly mentioned. The so-called *Antilope boödon* is referred to *Palæoryx*, while *A. torticornis*, Aymard, which has been shown in an earlier memoir to be intermediate between *Palæoreas* and *Tragelaphus*, is referred to the latter genus, although classed by M. P. Thomas with the former; the occurrence of these Antelopes allied to those of modern Africa at such a recent epoch is of much interest. *Sus arvernensis* is considered indistinguishable from *S. provincialis*, and closely allied to the existing African *S.* (*P.*) *africanus*. The *Hipparion* is identified with *H. crassum*, Gerv., and regarded as distinct from *H. gracile*; and it is suggested that the Montpellier form may also be the same. The Rhinoceros is referred to *R. megarhinus* (*leptorhinus*), but (apart from the evidence of the imperfect cranium) it appears to us almost certain that the dentition represented on pl. i. belongs rather to *R. etruscus*—the teeth being apparently brachydont, the upper premolars showing the strong horizontal cingulum and the third costa characteristic of that species, and the lower molar also exhibiting the distinctive cingulum at both extremities. Among other interesting forms we may mention *Testudo Perpiniana*, which is as large as *T. elephantina*, and a spine indicating the occurrence of a Siluroid which it is suggested may be allied to *Clarias*.

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[1] We have already been obliged to quote such subfamilies in the same rank with families.

[2] Thèses Présentés à la Faculté des Sciences de Paris, sér. A. No. 67, pp. 1–268, pls. i.–v. (1885). The writer of this notice regrets that the work did not come into his hands in time to incorporate some of its information in the British Museum Catalogues.

[3] In a recent memoir (Bull. Soc. Géol. France, sér. 3, vol. xiii. pp. 287-94 [1886]). Prof. Gaudry defends the former view. Since the learned Professor admits the intercalation of Pliocene marine strata in the Pikermi beds, all his reasons appear to us (be it said with all respect) to present a strong savour of the kind of argument known as "begging the question."

Almost the only point with which we can find fault is the retention of names like *Machærodus Sainzelli* and *M. pliocænus*, which, if not mere synonyms, are from the want of figures of no possible value. The work, with other memoirs by the same author, will be indispensable to all future students of the Fossil Mammalia of France.

R. LYDEKKER.

III.—TRANSACTIONS OF THE CUMBERLAND AND WESTMORLAND ASSOCIATION FOR THE ADVANCEMENT OF LITERATURE AND SCIENCE. No. X. 1884-85.

FOUR papers of geological interest are contained in this volume. Mr. W. G. Collingwood discourses "On Lake-basins of the neighbourhood of Windermere," observing that those which do not lie in anticlinal or synclinal breaks coincide with faults. He has failed to find any evidence of ice-erosion in the minor lake-basins, although ice may have helped to free them from detritus. Mr. J. Postlethwaite contributes a paper on "Trilobites of the Skiddaw Slates," which is illustrated by four plates. The paper simply deals with the general characters of the specimens and with their localities, but few names being given. Great interest however attaches to them as many of the forms are new. These have been named by the author and Mr. J. G. Goodchild in a paper lately read before the Geologists' Association. Mr. H. W. Schneider communicates an article "On the Hæmatite Iron Mines of Low Furness," from which the total production of pig-iron amounts annually to about 550,000 tons; and Mr. J. D. Kendall replies to a previous paper by Mr. T. V. Holmes "On the Best Locality for Coal beneath the Permian Rocks of North-west Cumberland."

We took occasion when noticing a former Part of these "Transactions" to observe that the plan of the Cumberland Association might well be adopted in other counties, where more than one Natural History Society exists. A very proper rule is to print only those papers which are *local* and *original*. We regret to learn that on account of this rule, the Whitehaven Scientific Association has severed its connection with the Cumberland Association. Surely unity is strength, and surely there are members of the Whitehaven Association who could aid in the progress of science without departing from the salutary rules framed for the benefit of the many. The multiplication of local "Transactions" is a serious evil.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—May 26, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "Further Proofs of the Pre-Cambrian Age of certain Granitoid, Felsitic, and other Rocks in North-western Pembrokeshire." By Henry Hicks, M.D., F.R.S., F.G.S.

In this paper the author gave the results obtained by him during a recent visit to N. W. Pembrokeshire. He stated that he had further examined some of the sections referred to in his previous papers, as well as others not therein mentioned, and that he had obtained many additional facts confirmatory of the views expressed by him in those papers. The Lower Cambrian conglomerates and grits, he said, contained pebbles of nearly all the rocks in that area which he had claimed as of pre-Cambrian age; and the fragments of the granitoid rocks, the felsitic rocks, the hälleflintas, and of the various rocks of the Pebidian series which he had found, showed unmistakably that those rocks had assumed, in all important particulars, their peculiar conditions before the fragments were broken off.

Moreover, he stated that there was abundant evidence to show that the very newest of the pre-Cambrian rocks of the area had been greatly crushed, cleaved, and porcellanized, before any of the Cambrian sediments were deposited; hence he maintained that there was in the area a most marked unconformity at the base of the Cambrian. At Chanter's Seat, near St. David's, he found that the Lower Cambrian grits and conglomerates were, in parts, almost wholly made up of fragments of characteristic varieties of the Granitoid rocks which form the Dimetian ridge near by.

The so-called granite of Brawdy, Hayscastle, and Brimaston, he said, there was good evidence to show, was probably of the age of the Granitoid rocks of St. David's. The mass of so-called granite near Newgale, he stated, was composed of rhyolites and breccias, undoubtedly of pre-Cambrian age.

The Roch Castle and Trefgarn rocks, he stated, could not possibly be intrusive in Cambrian and Silurian strata, but belonged to a series of pre-Cambrian rocks. He referred to the important evidence bearing on the age of these rocks given in a paper communicated to the Society, since his last paper was read, by Messrs. Marr and Roberts. These authors showed that in a quarry near Trefgarn

Bridge a Cambrian conglomerate, overlain by *Olenus*-shales, is to be seen resting on the eroded edges of the Trefgarn series. The author examined this section lately, and obtained from the Conglomerate some very large pebbles of the characteristic rocks called hälleflintas, and of the ash-bands, both of which are found *in situ* in the quarry. He therefore maintained that there was the most ample evidence to show that there was a great group of pre-Cambrian rocks exposed in N.-W. Pembrokeshire, and hence that he had proved conclusively that Dr. Geikie's views in regard to these rocks, as given in his paper and more recently in his text-book, are entirely erroneous.

2. "On some Rock-specimens collected by Dr. Hicks in North-western Pembrokeshire." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author stated that he had examined microscopically a series of specimens collected by Dr. Hicks, and compared them with those described by Mr. T. Davies, in vol. xl. of the Quarterly Journal, and with some in his own collection. He agreed with Mr. Davies's conclusions in all important matters.

The Chanter's-Seat conglomerate contained many grains of quartz and felspar, curiously like those minerals in the so-called Dimetian, together with numerous small rolled fragments, about a quarter of an inch in diameter, exactly resembling the finer-grained varieties of that rock, besides bits of felsite, similar to some which occur in the St. David's district, quartzite, a quartz-schist, and an argillite.

The rocks *in situ* in the Trefgarn quarry were indurated trachytic ashes, together with the curious flinty rock which was the most typical of the so-called hälleflintas. One of the pebbles from the overlying conglomerate perfectly corresponded with the last-named rock, others appeared to be most probably from an altered trachytic ash, differing only varietally from those *in situ*.

After prolonged examination of this "hälleflinta" of Trefgarn and the similar rocks from Roch, he was of opinion that while it was possible that some specimens might be altered ashes, most of them were originally rhyolites or obsidians, devitrified, and then silicified by the passage of water which had contained silica in solution. The Trefgarn group obviously could not be intrusive in the Lower Cambrian, and it was extremely improbable that the Roch Castle series was newer than the basement conglomerate of that district.

The Brawdy granitoid rock might be a granite, but at any rate it presented considerable resemblance to the "Dimetian."

It was therefore evident that the Cambrian conglomerate of St. David's was formed from a very varied series of rocks, some of them much older than it, and that the Dimetian could not be intrusive in it. Moreover, even if the Dimetian should be proved ultimately to be a granite, and the core of a volcano which had emitted the rhyolites, sufficient time must have elapsed after its consolidation and prior to the making of the conglomerate to remove, by denudation, a great mass of overlying rock. Hence, whatever its nature, it was pre-Cambrian.

3. "On the Glaciation of South Lancashire, Cheshire, and the

Welsh Border." By Aubrey Strahan, Esq., M.A., F.G.S., H.M. Geological Survey. By permission of the Director-General.

Part I. SOUTH LANCASHIRE AND CHESHIRE.

The average direction of the large number of glacial striæ which have been observed in the neighbourhood of Liverpool is N. 28° W. Further up the Mersey there is a slight deflection towards the east. Two instances only occur of striæ having a totally different direction, namely E.N.E. The striæ themselves seldom furnish any evidence as to the direction in which the ice travelled, but the edges of the strata have in many cases been bent back from the north-west. The materials of which the drift is composed, both matrix and included boulders, have also travelled from the north-west. The sands and gravels also are arranged in long banks, trailing away from the south-west sides of the rock-hills, in such a way as to show that they were distributed by currents from the north-west. The striæ are found in connexion with the Boulder-clays, in which the actual presence of ice is abundantly proved. Presumably the same agent that distributed the Boulder-clay also striated the rock-surface and moved from the north-west.

Part II. THE WELSH BORDER.

The striations within the Welsh Border also show a general parallelism, but in a direction E.N.E., the few exceptions that occur being close to the Border. The direction in which the drift has been transported shows a corresponding change; though analogous in arrangement to the Lancaster drift, it has all travelled from W.S.W. to E.N.E. The boundary between the northern drift of the English side and the western drift of the Welsh runs approximately along the coast, bending inland here and there, and cutting inland across parts of South Flintshire and Denbighshire. The transportation of the Welsh drift has taken place across the lines of the principal hill-ranges and valleys. Occasionally the two drifts shade one into the other, or are mixed together; but as a general rule the far-travelled northern drift overlies the more local deposit, and is easily distinguishable by its different materials and by its being comparatively stoneless.

It may be concluded that:—

1. The striæ on the English and Welsh sides respectively, while showing variations among themselves, by a marked preponderance in one quarter of the compass, indicate a direction of principal glaciation, this direction being on the English side from about N.N.W., and on the Welsh from about E.S.E.
2. The direction of glaciation in both districts agrees very closely with that of the transportation of the drift, but is only locally influenced by the form of the ground.
3. The striæ are by no means universal, but are found almost exclusively in connexion with those beds in the drift which contain evidence of the actual presence of ice.

Part III. ORIGIN OF THE STRIÆ.

The striæ are not such as can have been produced by valley-glaciers; they go across and not down the valleys, nor are there any moraines. The question resolves itself into (1) the hypothesis of two ice-sheets moving in different directions in the two areas; (2) that of floating-ice. The first is opposed by the facts that the rock-surface is not *moutonnéed* on a large scale, and that the striæ and terminal curvature are far from universal; that the drifts associated with the striæ are marine deposits; that striæ having different directions are found on the same slab. The well-known occurrence of gravel-ore in the drift at the outcrop of a vein is also against this hypothesis. The marine origin of the drifts is indicated by their well-marked stratification as a whole, by the alternations of well-washed sands and gravels with the Boulder-clays, and by the occurrence through all the beds of marine shells. A lower or basement-clay is seen in places under this marine drift, but it is always the latter with which the striæ are associated. The great development of undoubted marine beds and comparative rarity of *moutonnéed* surfaces constitute the principal differences between this region and the north, where the existence of an ice-sheet has been strongly advocated. Anglesey is considered by Sir A. Ramsay to have received its configuration by the action of an ice-sheet from the north; but its physical features appear to be due rather to its geological structure, and to have existed in more or less their present form in pre-glacial times.

The arrangement of drifts in this district presents an analogy with that of the Norfolk drifts, and probably results from a similar sequence of events.

The marine drifts, from their great variability, seem to have been distributed, and the striations produced by floating-ice, driven by tidal or oceanic currents, during the time of submergence. During this time Snowdon and the surrounding hills must have stood well above water, forming an island-group, and by such a group the prevailing currents from the north would be deflected to the south-west over Anglesey on the one side, and to the south-east over the plains of Cheshire and Shropshire on the other, while within the limits of the group a local circulation might be maintained.

II.—June 9, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Volcanic Rocks of North-eastern Fife." By James Durham, Esq., F.G.S., with an Appendix by the President.

After describing the general distribution of the volcanic rocks of Old Red Sandstone and Carboniferous age in the counties of Forfar and Fife, the author called attention to a fine section exhibited where the Ochil Hills terminate along the southern shore of the Firth of Tay. In immediate proximity to the Tay Bridge, a series of the later volcanic rocks, consisting of felstones, breccias, and ashy sandstones, are found let down by faults in the midst of the older porphyrites (altered andesites) which cover so large an area in the district. The breccias contain enormous numbers of blocks of a red dacite (quartz-andesite), and inclosed in this rock angular fragments of a glassy rock, resembling a "pitchstone-porphyry," are found, everywhere, however, more or less converted into a white decomposition-product. The youngest igneous rocks of the district are the bosses and dykes of melaphyre (altered basalt and dolerite), which have been often so far removed by weathering as to leave open fissures.

In the Appendix three very interesting rocks were described in detail. The rock of the Northfield Quarry, which is shown to be an augite-andesite, has a large quantity of a glassy base with felted microlites, and contains large porphyritic crystals of a colourless augite. The rock of the Causewayhead Quarries is described as an enstatite-andesite; it has but little glassy base, being made up of lath-shaped felspar crystals (andesine), with prismatic crystals and grains of a slightly ferriferous enstatite; there are no porphyritic crystals, but the enstatite individuals are sometimes curiously aggregated. The red porphyritic rock from the breccias near the Tay Bridge was shown to be a mica-dacite, and the glassy rock associated with it to be the same material with a vitreous in place of a stony base. This glassy base exhibits very beautiful fluidal and perlitic structures. The crystals of first consolidation in this rock are oligoclase and biotite, often showing marks of injury in transport; those of the second consolidation appear to be orthoclase. In conclusion, the successive stages by which the andesitic rocks of the area were altered, so as to assume the characters distinctive of porphyrites, were fully discussed, as well as the change of the glassy rock into its white decomposition-product.

2. "On some Eruptive Rocks from the Neighbourhood of St. Minver, Cornwall." By Frank Rutley, Esq., F.G.S.

The rocks described in this paper were derived from Cant Hill, opposite Padstow, and from a small quarry about half a mile from Cant Hill, near Carlion. At the former locality the volcanic rocks are much decomposed, but from their microscopic characters they may be regarded as altered glassy lavas of a more or less basic type. No unaltered pyroxene, amphibole, or olivine is to be detected in the specimens described, but there is a considerable amount of secondary matter which may include kaolin, serpentine, chlorite, palagonitic substances, etc. There is evidence of fluxion-structure in some of the sections; others are vesicular, and the vesicles are usually filled with siliceous or serpentinous matter. The relation of these lavas to the underlying Devonian slates was not ascertained. The rock occurring near Carlion contains numerous porphyritic crystals of augite, in which the crystallization is interrupted by the co-development of small felspar crystals, which appear, as a rule, to have been converted into felsitic matter. Ilmenite is also present in patches which indicate a similar interrupted crystallization to that shown by the augite. The rock has the mineral constitution of an augite-andesite; but since it is a holocrystalline rock, exception would be taken by many petrologists to the employment of the term andesite. The lavas of Cant Hill were also probably of an andesitic character, so that, so far as original mineral constitution is concerned, there is some apparent justification for the mapping of both of these rocks as "greenstone" by the Geological Survey.

3. "The Bagshot Beds of the London Basin." By H. W. Monckton, Esq., F.G.S., and R. S. Herries, Esq., B.A., F.G.S.

The authors stated that their object was to describe more fully the Lower Bagshot beds, and to disprove the view lately advanced by Mr. Irving that, in certain places, the Upper Bagshots overlap the Lower and rest directly on the London Clay. They described or referred to a number of sections all round the main mass, beginning at St. Ann's Hill, Chertsey, where they considered that the mass of pebbles and associated greensands must be referred to the Middle Bagshot. The outliers near Bracknell and Wokingham were shown to consist of Lower and not Middle Bagshot, which does not appear in the valley north of Wellington College.

The Aldershot district was explained, and it was shown that the beds there resting on the London Clay were Lower and not Middle Bagshot, and the occurrence of fossils in the Upper Bagshot of that district was recorded.

The conclusions that the authors came to were, that a well-marked pebble-bed was almost always present, marking the division between the Upper and Middle Bagshots, but that there were other pebble-beds of a less persistent character occurring both in the Middle and Lower Bagshot; that the Lower Bagshots generally consist of false-bedded sands with clay laminæ and no fossils except wood, whereas the Upper Bagshots are rarely false-bedded, and are characterized by the absence of clay bands and the presence of marine fossils; and that the Middle Bagshot is a well-marked series consisting of green sands and clays.

They claimed, in conclusion, that there was no reason for disturbing the old reading of the district, and that there was no evidence of an overlap of the Lower Bagshots by the Upper.

CORRESPONDENCE.

SLICKENSIDED SURFACES OF CHALK.

SIR,—Mr. H. Hutchins French, F.G.S., and I have discovered widely spread surfaces of chalk slickensided horizontally in the neighbourhood of Sutton, Surrey. There seems to be abundant evidence that these markings are really due to friction, and they are associated with a remarkable cleaved structure at a high angle to the bedding. This cleavage is very striking, and we should be glad to receive any notices of similar phenomena in the Chalk.

We also find the Thanet Sand to extend further west than was supposed to be the case, it being some 15 feet at Leatherhead, where it was supposed to have died out, or to have been overlapped by the Woolwich Beds.

We have prepared some interesting new sections in the Lower Tertiaries around Epsom, which we hope to publish shortly.

CARSHALTON, SURREY, SYDNEY B. J. SKERTCHLY.
May 10th, 1886.

MEMORANDUM FOR GEOLOGISTS VISITING WEYMOUTH.

SIR,—Driving from Weymouth the other day, I noticed some magnificent blocks of the cherty flint of Bincombe Down,[1] placed to be broken up for mending the road. This shows that the part of the Lower Eocene bed there is now open which contains these blocks. I would strongly advise any geologist visiting Weymouth, who is conversant with the Cretaceous series, to examine these blocks. If I am not mistaken, they represent some horizon which has entirely disappeared from the area. It does not seem to me quite certain whether they are flints, altered in texture, or whether they are chert. In shape and size they are like those which are and have been worked for implements at Brandon; but in texture they are quite different, being grey throughout and opaque, with many casts of fossils. Similar flints, containing similar fossils, occur in the extraordinary flint bed resting upon the Greensand of Haldon Hill, near Exeter: and there is a collection of the fossils in the Exeter Museum; as there is also a small collection of the Bincombe fossils at Dorchester.

The observer must not be deceived by certain flints to be seen in walls, etc., along the Weymouth road, which are not chalk flints, but come out of the Portland beds at Bincombe. They are usually nearly spherical in shape, and black inside. O. FISHER.

DOES *TEREDO* INHABIT FRESH WATER?

SIR,—I have found an account by Dr. E. P. Wright of a new *Teredo* which he names *Nausitoria* from the Ganges, in the Linnean Soc. Trans. 1864, p. 451. It is found in the river Comer, a loop which runs separately from the Ganges for 80 miles, when it rejoins the main river at Mandarapore, 70 miles from the sea. The water for 30 miles below Mandarapore is perfectly fresh, when it becomes slightly brackish at full tide; but in the Comer it is always quite fresh and soft and used for drinking, washing, etc. Trees and boats are however attacked by a *Teredo* in it, and hence Dr. Wright believes that at all events this species does live in perfectly fresh water. J. S. GARDNER.

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[1] See Damon's Geology of Weymouth and Portland, 2nd edition, p. 143.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. VIII.—AUGUST, 1886.

ORIGINAL ARTICLES.

I.—NOTE ON *EOPHYTON? EXPLANATUM*, HICKS, AND ON *HYALOSTELIA* (*PYRITONEMA*) *FASCICULUS*, M'COY, sp.

By GEORGE JENNINGS HINDE, Ph.D., F.G.S.

MR. W. CARRUTHERS, F.R.S., lately called my attention to the resemblance between some drawings I was showing to him of *Hyalostelia fasciculus*, M'Coy, sp., and the supposed fossil plant, described and illustrated by Dr. Henry Hicks, F.R.S., in the GEOLOGICAL MAGAZINE for 1869, Vol. VI. p. 534, Pl. XX. Figs. 1*a*–*e*, under the name of *Eophyton? explanatum*.

The following is the description given by Dr. Hicks of this fossil: "A raised moderately convex stem about four lines in breadth; widening however and becoming somewhat compressed at the joints. The surface is ribbed and furrowed along its whole length. At the lower joints, the ribs bend outwards, evidently to form a branch. The joint is obliquely placed, widened out, and its course distinctly marked by a deep sulcus. The cortical substance is very thin, and can be removed to show the internal structure. The internal structure is made up of compressed columns, running the whole length from joint to joint, evidently of a tubular nature, and bound together by very thin tissue."

Owing to the fact that no structure had been discovered in the type forms of the genus *Eophyton*, Dr. Hicks placed this fossil only provisionally under the genus, but he at the same time stated that there could be no reasonable doubt of its vegetable nature, and that its affinity to the vascular cryptogams was most clearly shown.

Its plant-characters, however, were not acknowledged by Mr. Carruthers, who wrote respecting it: "It is very doubtful whether this fossil belongs to the Vegetable Kingdom. The large-sized continuous tubes of which it is composed are unlike plant-structure" (Seemann's Journal of Botany, vol. viii. p. 13).

Subsequently, in the Quarterly Journal Geol. Soc. for 1881, vol. 37, p. 490, Dr. Hicks again refers to the same fossil in the following paragraph: "Of *Eophyton? explanatum*, which I found in the Tremadoc rocks of St. David's, I fear the evidence is scarcely sufficient to ally it with land-plants. Its strong tubular structure renders it unlike any known land-plant; and the only other fossil found yet, to which it can be compared, is the *Pyritonema* of Prof. M'Coy, placed by him amongst the Zoophytes, though its true nature is still a matter of much doubt."

Being desirous of ascertaining the true character of *Eophyton explanatum*, I applied to Dr. Hicks, who very kindly at once forwarded to me the original specimen, as well as two microscopic sections which had been prepared from it, and these very distinctly showed that Dr. Hicks was quite correct in his later comparison of the fossil to the *Pyritonema* of M'Coy. I have also been enabled to compare it with the type specimen of *Hyalostelia* (*P.*) *fasciculus*, M'Coy, belonging to the Cambridge Woodwardian Museum, which was kindly lent to me by Prof. T. McKenny Hughes, and also with examples of the same species in the British Natural History Museum, the Jermyn Street Museum, and others kindly forwarded to me by Mr. G. H. Morton, F.G.S., from Pont Ladies, Llandeilo.

Dr. Hicks's specimen is shown on the fractured surface of a slab of hard black shale, which, judging from the distorted forms of the Brachiopods in it, must have been strongly compressed. It has the appearance of an elongated, slightly convex band with delicate longitudinal striæ or ribs. The band, which is about 5·5 mm. in width and 1·5 mm. in thickness, can be traced continuously in a nearly straight direction throughout the slab; in one place it is slightly bent and traversed obliquely by an incomplete fracture, which was supposed by Dr. Hicks to be a joint in the stem, but which probably arises from compression in the rock. The band, for some distance, is enveloped by a thin coating of the shaly matrix, supposed to have been a cortical tissue; where this is absent, the constituent spicular rods are clearly exposed.

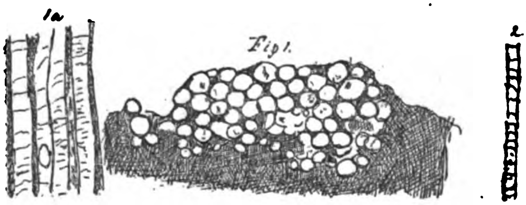

Fig. 1. *Eophyton ? explanatum*, Hicks = *Hyalostelia fasciculus*, M'Coy, sp. Transverse section of the bundle of spicular rods. From Dr. Hicks's type-specimen.
,, 1*a*. The same, showing longitudinal sections of some of the rods.
,, 2. A single spicular rod of *Hyalonema mirabile*, Gray. The figures are all drawn to the same scale of eight diameters.

The apparent band is, in fact, a bundle of solid, elongated, cylindrical spicular rods, disposed parallel to each other, and for the most part in close contact, but without any organic connection with each other. In some instances the rods are compressed together so as to become partially flattened, but originally they appear to have been circular in transverse section. The minute interspaces occasionally intervening between the rods are filled by the rock-matrix, and there are no traces of any enveloping structure inclosing the bundle. The rods vary from ·15 to ·5 mm. in thickness, they are now of chalcedonic silica, and for the most part solid throughout, in only a single instance did I see an indication of an axial canal. Delicate wrinkled lines cross the rods transversely and apparently represent the slight projecting frills met with in other specimens.

In all important characters, Dr. Hicks's specimen so closely resembles the typical example of *Hyalostelia* (*Pyritonema*) *fasciculus*, M'Coy,[1] that there is no reason to regard it as specifically distinct. The individual rods do not reach the maximum thickness of some of those in the typical form of the species, but the differences are not so great as to be of specific value.

Having established the similarity between these forms, it is desirable to point out that the relationship, indicated by M'Coy, of *Pyritonema fasciculus* to the glass-rope of *Hyalonema mirabile*, Gray, is of a genuine character. This has been called in question, amongst others, by Prof. G. Lindström,[2] who states that M'Coy's species "is nothing but a silicified and consequently somewhat altered *Heliolites*. It must be confessed that the purely diagrammatic figure given by M'Coy (Brit. Pal. Foss. pl. i. *B*, fig. 13*a*) might readily give rise to this conclusion. Prof. F. Roemer[3] also states that the systematic position of the genus, in which species allied to the present one are placed, is very uncertain. I also found the specimens of this species in the Jermyn Street Museum, placed with the Annelida of the Llandeilo group, probably on account of their close resemblance to *Hyalostelia* (*Serpula*) *parallela*, M'Coy, sp., from which they can hardly be distinguished.

At the time when M'Coy compared *Pyritonema fasciculus* with the rope of *Hyalonema mirabile*, Gray, the true sponge nature of this latter form was stoutly denied by Dr. Gray, who then regarded the rope as the skeleton of a Zoophyte, and M'Coy also adopted this opinion. It is now well known that ropes or tufts of long spicular rods are common appendages in many of the deep-sea hexactinellid sponges, and the resemblance of these to the fossil forms is very striking.

In both recent and fossil examples there is a similar form and arrangement of the spicular rods in bundles; the rods correspond in dimensions, in their siliceous composition, and, when the fossil forms are well preserved, in the possession of axial canals, and even the concentric layers of the rods can be seen. In some species, though not in the present one, some of the fossil rods terminate in four recurved hooks, precisely as in the recent examples. In another structural feature also, which has not hitherto been particularly noticed, there is a well-marked correspondence between *Hyalostelia fasciculus* and the recent *Hyalonema mirabile*. This is the occurrence, on the surface of some of the rods, of minute annular or spiral projecting ridges or frills, which look like so many wrinkled lines crossing the rods. The frilled rods are irregularly interspersed in the same bundle with others having smooth, even surfaces, in some cases most of the rods are provided with frills, whilst in others there is only about one in ten or twenty with them. In the recent *Hyalonema mirabile* some of the spicular rods are also provided with projecting spiral fringes of a similar character to those in the fossil form, but when perfect the frills are armed with minute spines.

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[1] Brit. Pal. Foss. p. 10, pl. i. *B*. fig. 13.

[2] Bih. till K. Svenska Vet. Akad. Handl. Bd. 8, No. 9, 1883, p. 13.

[3] Lethæa Palæozoica, 1880, p. 318.

At present, definite hexactinellid spicules have not been found in the same strata with *H. fasciculus*, but this negative fact can hardly be employed as an argument against the sponge-character of the spicular bundles. As these latter were, in the life-time of the sponge itself, imbedded in the muddy bottom of the ocean, they were not liable to be disturbed and dispersed after the death of the animal, in the same manner as those of the body of the sponge, and this same fact will also account for the preservation of the ropes or bundles of spicules with their constituent spicular rods in their natural positions.

The specimen discovered by Dr. Hicks in the Tremadoc rocks of Wales thus establishes the presence of siliceous hexactinellid sponges with anchoring appendages of bundles of spicular rods, at this horizon, and the same species also occurs at Trefil and at Pont Ladies in the Llandeilo rocks.

Allied species of *Hyalostelia* are recorded by Nicholson[1] and Etheridge from Ordovician strata in the Girvan area; by Prof. Ferd. Roemer[2] from Lyckholm strata (= Bala) in Esthland, and in the drift of Sadewitz;[3] and they are very abundant in Lower Carboniferous beds in Scotland, Ireland, and Yorkshire.

The genus *Hyalostelia*, in which the *Pyritonema fasciculus*, M'Coy, is now placed, was proposed by Zittel[4] to include sponges, with an upper portion of regular hexactinellid spicules and an anchoring appendage of elongated spicular rods.

In conclusion mention may be made that Dr. Hicks has presented his original specimen to the British Natural History Museum.

II.—ON A NEW SPECIES OF *AXOSMILIA* (*A. ELONGATA*) FROM THE PEA GRIT OF THE INFERIOR OOLITE OF ENGLAND.

By Professor P. MARTIN DUNCAN, M.B. (Lond.), F.R.S., etc.

MANY years since, Mr., now Prof., Ralph Tate gave me a small slender coral, which he had obtained from the Pea Grit of the West of England. I had just completed the Supplement to the British Fossil Corals, Pal. Soc., so the fossil has remained undescribed.

It has lately been determined to publish a new edition of the late Prof. J. Morris's Catalogue of British Fossils, and therefore, in order to render the Madreporarian part of that work as complete as is possible, I have studied and now describe the species.

The specimen is well preserved, except in the calice, but the deficiency is compensated by an excellent section close below.

The narrow peduncle of the form has been broken from its attachment, and there are no structures which denote that the form was

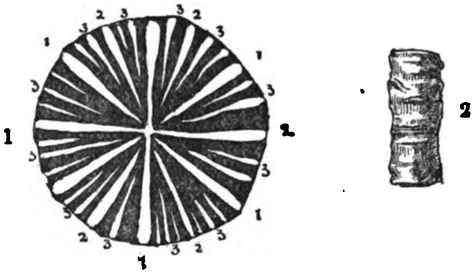
[1] Mon. Sil. Fos. Girvan, fasc. ii. p. 239, pl. xix. figs. 1–1*b*.

[2] Lethæa palæozoica, 1880, p. 318.

[3] Foss. Fauna von Sadewitz, p. 55, pl. vii. figs. 7*a*, 7*b*.

[4] Handbuch der Pal. vol. i. p. 185.

otherwise than a simple, tall individual, attached, like many simple corals, to a foreign body. The epitheca is strong, and, as is usual in the genus, is remarkably ringed with ***bourrelets d'accroissement***, or growth-rings, so that the surface is tumid and constricted consecutively about thirteen times in the height of 37 mm. No abrasion of the epitheca has occurred, and there are therefore no septa to be seen on the flanks of the coral from wearing in. The inside of the coral is filled with a brown homogeneous calcite, and the septa and columella are white in colour. The condition of preservation is very fair, but it appears that some destructive action proceeded, for a septum of the fourth order is missing here and there, a fifth being present.



Axosmilia elongata, sp. nov., Pea Grit, West of England. 1. Transverse section (enlarged five times). 2. Interior (natural size).

Axosmilia elongata, sp. nov.—Corallum simple, tall, straight, cylindrical, with a small peduncular attachment which leads upwards to a conico-cylindrical stem, terminating in a cylindrical top; diameter one-fifth of the height.

Epitheca strong, marked with narrow rings and alternate swellings and constrictions. Wall merging into the epitheca, epithecate wall thin. Calicular section nearly circular in outline.

Septa well developed, eight long and stout reaching the small, essential, styloid, slightly compressed columella. Six of these are primaries and two are secondaries, the other secondaries being smaller. Tertiary septa long, slender, and often having a paliform knob at the inner end, not always straight. The higher orders are small and somewhat irregularly developed (unless absorption of some others has taken place). The bases of the septa at the thin wall are large, and the laminæ become slender towards the columella. Probably the correct cyclical arrangement is four systems with four cycles, and two systems with three cycles and part of a fourth, but the following can be seen.

Two systems with three cycles of septa and one septum of the fourth order in each. Two systems with four cycles complete, the fourth and fifth orders of the fourth cycle being placed as is usual in other Madreporaria. A system with three cycles and two members of a fourth cycle, but in one half-system there is a septum of the fourth order, and in the other half-system there is no septum of the fourth, but there is one of the fifth order; this being anomalous, it is probable that the fourth order of the half-system has been lost.

A system with three cycles complete and the fourth cycle represented by septa of the fourth and fifth orders in one half and by a septum of the fourth order only in the other half-system.

Endotheca scanty. Costæ absent. Height 37 mm. Breadth of section 6 mm.

The distinctness of the species from *Axosmilia Wrighti*, Ed. & H., is evident; but the incomplete cyclical arrangement of the septa allies the species to *A. extinctorium*, Mich., sp. The tertiary septa of this last species are said by Ed. & Haime to unite with the secondaries close to the columella; this does not occur in the new form, which moreover has little knobs resembling paliform lobes at the inner ends of some septa as seen in the section.

The question arises almost of necessity, Was this coral a solitary or simple form? The straight shape, the absence of lateral adhesion markings, and the deficiency of any gemmation, indicate the simple nature; moreover, there are no signs of continuity between the base of the specimen and a parent stem. Nevertheless, it must be remembered that certain fasciculate corals might present pieces of a shape similar to the new form; but no one has been found with the special characters of the calicinal section described above. It appears that Milne Edwards and Jules Haime were correct in placing *Axosmilia* amongst simple corals; but the present species is more elongate and less expanded superiorly than their type. The new form differs from all others, and from all parts of forms which have been described from the Lower Oolite series.

The specimen is now in the British Museum.

III.—MESOZOIC ANGIOSPERMS.

By J. S. GARDNER, F.G.S.

(PLATE IX.)

SINCE the article on Mesozoic Angiosperms was written,[1] a very important Sketch History of "Palæobotany," by Lester F. Ward, has appeared in the Fifth Annual Report of the U. S. Geol. Survey, a brief outline of which cannot fail to prove of interest in connexion with this subject. The object of the sketch is to collate and reduce the fragmentary and desultory mass of information collected by previous writers into a system that will enable geologists to use the testimony of fossil plants, in the same way that they habitually use that of fossil animals. The author laments that botanists and palæobotanists have worked and classified almost wholly independently of each other, the former having consequently missed such important data for classification as the order in time in which each type appeared, while the latter have failed to harmonize their work with the more elaborate and best botanical systems, and hence greatly lessened its practical value. "Every candid palæobotanist must admit that he can understand fossil plants only as they resemble living ones, and that the botanist, studying the per-

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[1] See GEOL. MAG., May, 1886, pp. 193-204.

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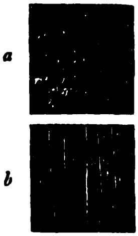

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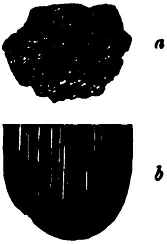

FIG. 1. Palmwood from the Gault, Folkestone.

FIG. 2. Palmwood from Antigua, W. Indies.

a. transverse section. *b.* longitudinal section.

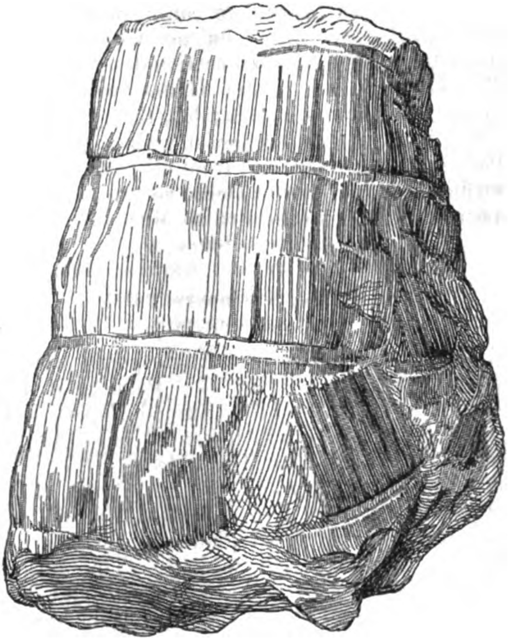

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FIG. 3. Stem of the so-called *Calamites Beanii*, Bunbury,[1] from the Inferior Oolite near Scarborough, "one of the Arborescent Gramineæ" (Williamson).

[1] This is the figure referred to on p. 202, GEOL. MAG. May, 1886, as having been lost.—EDIT.

fect specimen with all its organs of reproduction as well as of nutrition, can alone declare with absolute certainty upon its identity or affinity." This mutual dependence requires recognition at the hands of scientific men.

The interesting collection of biographies of eminent palæobotanists is a feature of the work which can be but briefly alluded to here. The names that stand out prominently, and to whom half the literature is credited, are Brongniart, Göppert, Unger, Lesquereux, Heer, Massalongo, Ettingshausen and Saporta; but the biographies are 22 in number, and include the names of our countrymen Witham, Binney, Bunbury, and our eminent and yet living contemporaries Williamson, Dawson, and Carruthers. Of Prof. Williamson, he says: "Of the merits of this work, as of all this author's investigations, it is certainly unnecessary to speak here." Of Dawson: "A geologist rather than a botanist, he has done excellent service, not only in elucidating the important problems of Acadian geology, but also in demonstrating the value and legitimacy of the evidence furnished by vegetable remains." The value of Carruthers' work also receives due acknowledgment, his investigations with regard to fossil fruits having especially "widely expanded this field of knowledge." That Mr. Ward has gracefully acknowledged our indebtedness to these authors no one will dispute, but some may think the praise in other cases has been a little indiscriminate, and that a more critical examination into the quality, as well as the bulk of the work produced, would have rendered greater service to botanists who may require to have recourse to it.

It appears that Walch (1769) was the first to offer anything like a nomenclature of fossil plants, though a few terms such as *Lithoxylon* had for some time previously been in use. *Calamites* is the only one of his names, except *Carpolithes*, that has survived, and this was applied under the misconception that the plants in question were large reeds. Steinhauer (1818) was the first to apply specific names to fossil plants. Schlotheim soon afterwards[1] introduced, among others, two terms which specially interest us, *Palmacites* and *Poacites*, describing respectively 15 and 4 species. Sternberg[2] established the genus *Flabellaria* (I am purposely omitting all reference to Cryptogamic and Gymnospermous genera, in order to concentrate attention on the successive steps by which our knowledge of fossil Angiosperms has been arrived at), and assumed three periods of vegetation, that of Coal-plants, that in which Cycadean types predominated, and that of fucoids and dicotyledons, corresponding of course with the three ages of geology. The system of Martius, which should be interesting, is unfortunately passed over, and we are brought down to Brongniart's first memoir,[3] in which the only genera that interest us are *Exogenites* and *Endogenites*, to include stems whose internal organization is recognizable. Many Angiospermous fruits, leaves and stems had been figured, and more or less described, before this time, for example by Parkinson and Mantell, but none scientifically. In 1828 Brongniart's "Prodrome" appeared, in which he discards his previous artificial classification, and adopts a botanical one. The Gymnospermous were separated from the Angiospermous Phanerogams, the former being considered intermediate between the Cryptogams and true Phanerogams, a proposition which, though placed every year on a firmer basis, is not yet adequately recognized by botanists. Brongniart's system was accepted by almost all writers on the subject, with the notable exception of Lindley and Hutton, who included Cycads and Conifers among Exogens or Dicotyledons, a method still followed, unfortunately for palæontologists, by some of the ablest botanists of the day. They further included *Stigmaria*, *Annularia* and *Asterophyllites* among true Dicotyledons, *Noeggerathia* is placed among the Palms, and *Calamites* is attached to *Juncus*. "One of the most remarkable aberrations of the book," Mr. Ward remarks, "is the pertinacity with which the authors contend for the existence of Cactaceous and Euphorbiaceous plants in the Coal-measures." They in fact utterly ignored the principles laid down by Brongniart and previous writers, and entirely dissented from the theory of progressive development. Cotta's important treatise on fossil wood was followed a year later, in 1833, by Witham's work on the same subject, and by Zenker's[1] description of Cretaceous plants from Blankenburg in the Harz district, the first attempt to treat dicotyledonous fossils systematically. In 1840, Rossmässler proposed[2] to modify Sternberg's method of classifying all fossil dicotyledonous leaves as *Phyllites*, substituting a compound from it and the genus to which the leaves seemed to belong, as *Daphnophyllites*, etc. Thenceforward the plan of naming and describing fossil as if they were real plants, became definitely adopted. The terms *Carpolithes*, *Phyllites*, etc., are still employed where there is absolutely no means of assigning a fossil to any definite group in the vegetable kingdom, but the tendency is far greater towards unwarrantably assimilating leaves with living genera which they resemble, than the employment of any termination, such as "ites," *e.g.* *Pinites*, to suggest that the resemblance may be only apparent.

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[1] Petrafactenkunde, 1820.

[2] Flora der Vorwelt.

[3] Mém. du Musée d'hist. Nat., Paris, 1822, vol. viii. pp. 209-210.

Passing on to the question of classification, the result of palæobotanical research so far has been to necessitate certain modifications in order to bring the botanical system into accord with the successive appearance of classes of plants in time. The grouping that best meets this requirement is according to Mr. Ward:

- Cryptogams
- Phænogams
  - Gymnosperms
    - Cycadaceæ
    - Coniferæ
    - Gnetaceæ
  - Angiosperms
    - Monocotyledons
    - Dicotyledons
      - Apetalæ
      - Polypetalæ
      - Gamopetalæ

The chief modification introduced is the elevation of the Gymnosperms to the rank of a *class*, while the Monocotyledons and

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[1] Beiträge zur Naturgeschichte der Urwelt, Jena, 1833.

[2] Beiträge zur Versteinerungskunde, vol. i. die V. des Braunkohl. aus der Gegend von Altsattel in Böhmen.

Dicotyledons are reduced to *sub-classes*. This is done because the distinction between open and closed ovaries is regarded as a class distinction, and Gymnosperms are not dicotyledonous, but have a variable number of cotyledons ranging from 1 to 15. The conclusion that Gymnosperms form a natural transition from Cryptogams to the higher flowering plants has been arrived at by Sachs and others quite independently of the evidence of fossils.

Valuable statistics have been collected as to the actual numbers of species described, and we find, so far as Angiosperms are concerned, the result to be as follows: For the Carboniferous 8 or 0·5 °/₀, Permian 3 or 0·9°/₀, in the Bunter 4 or 18·2°/₀, Keuper 1 or 2·4 °/₀. For the Jurassic we have 1 or 0.8 °/₀ in the Rhætic, 5 or 3·7 °/₀ in the Lias, 9 or 2·1 °/₀ in the Oolite, and inexplicably enough only 1 or 0·8 °/₀ in the Wealden. The absence of flowering plants in this formation is one of the mysteries of the Geological Record which Mr. Ward does not elucidate. Vast delta deposits, such as these, composed of most varied kinds of sediments, spread over many and wide areas, in places teeming with plant and other remains of terrestrial life, would appear in every way fitted to have preserved fair representative examples of the vegetation of the period; yet, though monocotyledonous flowering plants must have been far from uncommon then, only a solitary one has been met with. To the close of the Jurassics only monocotyledonous Angiosperms are found, but with the Cretaceous Dicotyledons join them, and the percentage gradually increases until in the Laramie it reaches 37·5 °/₀, a figure only surpassed in the so-called Paleocene. The Eocene would appear the age of Monocotyledons, judged by the 16·8 °/₀, though the Miocene possesses no less than 272 species. Mr. Ward's tables have a statistical value, and enable us to see how far we are advanced; but it is needless to say that even the revision of Mesozoic Angiosperms in the preceding pages of this MAGAZINE has profoundly modified the per-centages of the group in the Jurassic. The supposed Carboniferous and Permian Monocotyledons rest on wholly unsatisfactory material, and Angiosperms cannot at present be traced with any approach to certainty farther back than the Mesozoic period. The value of such a table is again lessened by the possibilities of error in correlating the formations of the two hemispheres. If, for instance, we took the Lower Cretaceous of Europe, we should have a complete absence of Dicotyledons; but if we take the supposed equivalent of the Gault in America, we have "many of our most familiar forms, the poplar, the birch, the beech, the sycamore, and the oak;" "the fig tree, the true laurel, the sasafras, the persimmon, the maple, the walnut, the magnolia, and even the apple and the plum." That the American correlations of the Cretaceous and Eocene deposits of the Western hemisphere with ours, are faulty, becomes more and more apparent, and that many of the Dakotah plants actually belong to the genera quoted is still more open to question. Destructive criticism will, for a long time to come, do more to advance this study than any additions to species, and it is sincerely to be hoped that Mr. Ward or some other competent palæobotanist will devote himself to this side of the problem.

IV.—NOTES ON SOME HORNBLENDE-BEARING ROCKS FROM INCHNADAMPF.

By J. J. H. TEALL, M.A., F.G.S.

IN the present communication I propose to describe the petrographical characters of some hornblende-bearing rocks which occur as intrusive sheets and bosses in the limestones and quartzites of the Assynt district. These rocks have been referred to under various names by the different writers on the geology of the district. Prof. Nicol speaks of them as greenstone[1] and trap,[2] and Sir R. Murchison, as syenitic greenstone.[3] Mr. Hudleston[4] indicates their character more definitely by speaking of them as a "kind of diorite." Prof. Bonney, in an appendix to Dr. Callaway's paper "On the Newer Gneissic Rocks of the Northern Highlands," describes the microscopic structure of a specimen from the Traligill Burn near Inchnadampf, and designates the rock a hornblendic porphyrite. Dr. Heddle[5] gives some valuable information as to the distribution of the rocks, and calls attention to the perfection of form exhibited by the hornblende in certain varieties. He gives a figure of the hornblende which shows the forms (110), (010) and (011). With regard to the relations of the rocks to the associated strata he speaks somewhat doubtfully, but evidently inclines to the view that they are intrusive. That this is the case seems proved by the absence of vesicular structure and associated tuffs, and by the fact that although they keep as a rule parallel with the bedding, cases occasionally occur in which they can be seen to move from one horizon to another.

Mr. Hudleston has remarked on the fact that the igneous sheets have been involved in the earth-movements which have folded and faulted the stratified rocks, so that the date of intrusion must lie between the formation of the limestones and the production of the earth-movements which have produced such striking effects in this district.

The specimens on which the following observations are based were mainly collected by myself during the years 1883 and 1884. I am, however, indebted to Prof. Judd for the loan of some which he collected. Those collected by myself were partly obtained from the limestone and partly from the quartzite. Those from the limestone came from the bed which is so well exposed in the Stronchrubie escarpment about three-quarters of a mile south of Inchnadampf, and from the low ground to the north of Inchnadampf, where the rock is exposed in many places. Those from the quartzite came from two localities; one at a point where the 500-feet contour-line crosses the southernmost of two small burns which run into the Calda Burn (Alt á Chalda Mòr) near the most southerly portion of its course, and the other near the base of Beinn an Fhurain, rather more than a mile E.S.E. of Inchnadampf. Prof. Judd's specimens came from the neighbourhood of Inchnadampf, and from a point on the Allt nan

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[1] Q.J.G.S. 1856, p. 25. [2] *Ibid.* 1860, p. 97. [3] *Ibid.* 1859, p. 220.
[4] GEOL. MAG. 1882, p. 392. [5] Mineralogical Magazine, 1883, p. 138.

Uamh, south of Stronchrubie, at a height of about 700 feet above the sea.

CHARACTERS OF THE ROCK-FORMING MINERALS.

Hornblende.—As this is the mineral which especially characterizes the rocks in question, it will be well to describe it in the first place. It must be remembered, however, that this does not imply that hornblende is always the most abundant mineral. In almost all cases it occurs in well-formed crystals. The larger ones are found in the rock associated with the quartzite. They form short stout prisms, which, however, so far as my observations go, are not terminated by clinodomes (011) as in Dr. Heddle's figure, but by the positive hemipyramid ($\bar{1}11$) and the basal plane (001). The forms in the prismatic zone are (110) and (010). The smaller crystals occur usually in elongated prisms, and can only be studied in a satisfactory manner by the use of the microscope. Cross-sections sometimes show the ortho- (100) as well as the clino-pinacoid (010).

The larger crystals may sometimes be completely detached from the rock-mass, and are of such a size that their angles may be measured with a contact goniometer. In all cases the hornblende is green when examined in thin sections. The pleochroism is fairly strong; a = pale-green or yellowish-green, β and γ = deep-green, with only slight differences. One of the most interesting features is the presence, in certain varieties of the rock, of a marked zonal banding, due to a variation in depth of tint in the successive zones. In some crystals a very large number of zones may be detected; in others only two, and in others the crystal appears homogeneous. All these variations may be seen in one and the same rock-section; a fact which seems to show that the crystals have not been simultaneously developed. The zones are in all cases parallel with the external boundaries of the hornblende, except where an original crystal has been obviously fractured and a fragment only is present.

Twinning is frequently present, and the most common type is that in which the orthopinacoid (100) is both twin-plane and face of composition. Sometimes repeated twinning on this plan occurs, so that a crystal is made up of three or four lamellæ.

The alteration of the hornblende is accompanied by the formation of chlorite, epidote, and opacite. In some of the more altered rocks the hornblende is entirely represented by a green chloritic aggregate, in which specks of opacite are abundantly scattered. In these cases the form of the original hornblende is perfectly preserved. In other cases granular epidote is associated with chlorite, and in others epidote occurs to the exclusion of chlorite. In the last-mentioned cases the original form is often lost.

Felspar.—In some of the rocks two generations of felspar may be recognized. The larger porphyritic felspars possess sharply-defined crystalline outline. They occur in moderately thick tables, with conspicuous development of the clinopinacoid (010), and often show a most beautiful zonal banding due to variation in the optical characters of successive layers. Twinning according to the albite, pericline and probably also the Carlsbad laws occurs; but it is not very constant or uniform. These felspars also evidently possessed inclusions arranged in a more or less zonal manner; but the original nature of these inclusions is difficult to make out in consequence of alteration. It is a noticeable fact that the angles of the inner zones are mostly rounded, although the external faces of the crystals meet in perfectly sharp angles. In some specimens in which the felspars of the first consolidation have been so altered as to have lost to a very great extent their definite optical characters, irregular scales of a vividly polarizing mineral are seen to be scattered through the crystals. These scales often have their long axes arranged in a zonal manner, evidently corresponding with the original structure of the crystal. When examined with a high power, they are seen to possess one strongly-marked cleavage, and to extinguish parallel with this cleavage, so that they may be referred with confidence to a white mica, probably paragonite. The felspars of the ground-mass form together with quartz a microcrystalline aggregate.

In a large number of rocks only one generation of felspars can be detected. When this is the case, the individuals occur as irregular grains, sometimes of considerable size. Mutual interference appears to have prevented the development of definite form. Twinning on the albite plan is sometimes present and sometimes absent. In all cases the felspar-aggregate plays the rôle of ground-mass, and hornblende crystals lie in it, without any regard to the orientation of the individual grains. The coarseness of this aggregate varies between wide limits, sometimes it is so fine as to merit the term microcrystalline, at other times it is so coarse as to remind one of the structure of a medium-grained granite. In some of the thin intrusive sheets the felspars tend to assume the form of small columnar crystals, which give narrow lath-shaped sections, but even in these cases the outlines are not well defined.

Pyroxene.—This mineral is not constantly present. It is pale green when examined on a fractured surface of the rock, but perfectly colourless in thin section. It occurs in somewhat imperfect crystals and also as grains and granular aggregates. The forms of the crystals appear to be those characteristic of the common rock-forming augites. The maximum extinction in the prismatic zone is about 40°. The only cleavages recognized are those of the prism. The mineral has been especially noticed in the rocks which are intrusive in the dolomitic limestone; but it varies very much in quantity even in these, sometimes being absent altogether, and at other times occurring more abundantly than the hornblende. In some of the coarse-grained rocks in which the hornblende attains a considerable size it occurs as inclusions in this mineral. As a good deal has been said about the secondary origin of the rock-forming hornblende, it may be as well to state that no doubt whatever can exist as to the distinctness of the hornblende and the augite in these rocks. Fractured crystals of beautifully-zoned hornblende occur in the porphyritic varieties, and this must be regarded as absolutely conclusive in favour of the view that this mineral was a product of the consolidation of the original magma.

Apatite.—This mineral occurs in the form of limpid hexagonal crystals, which are usually four or five times longer than broad.

Magnetite.—A small amount of original magnetite occurs in grains and crystals. The opacite (secondary magnetite?) which occurs associated with the chlorite has already been referred to.

Calcite occurs in the form of fine dust thickly scattered through some of the more altered specimens, and also as large crystalline plates in sections which contain the colourless pyroxene. It is possible that the portions of crystalline calcite may be fragments of the limestone caught up by the igneous magma at the time of its intrusion.

Epidote has already been referred to in describing the alteration of the hornblende. It is difficult to say whether all the epidote has been formed in this way.

Quartz is present as a secondary and probably also as a primary constituent in some varieties of the rock.

Mica arises in connection with the alteration of felspar, and it is sometimes found associated with ill-defined aggregates of epidote.

DESCRIPTION OF THE ROCKS.

Macroscopic examination shows that the above minerals occur in very different proportions in the different varieties of the rock. In some the hornblende is very abundant, and these as a rule have a granular aspect; in others it is comparatively scarce. The latter usually contain two generations of felspar and have a marked porphyritic aspect. For the purpose of description we will term them hornblende porphyrites, and the former diorites. It must be remembered, however, that the diorites tend to become porphyritic by the conspicuous development of hornblende; such varieties will be termed porphyritic diorites. The diorites also present us with varieties of texture depending on the coarseness of the grain. In some the constituent minerals may be easily recognized, in others they are so small as to require the microscope for their determination. The latter occur in the thin sheets and at the margins of the intrusive masses.

In the porphyritic diorite near the base of Beinn an Fhurain concretionary patches occur which are more coarsely crystalline and richer in hornblende than the main mass of the rock. In these patches as in the main mass an aggregate of felspar individuals plays the rôle of ground-mass. As a rule the outlines of the inclusions are smooth and curvilinear, but sometimes the large hornblende crystals project for a short distance into the main mass of the rock. It is clear that we have here phenomena similar to those described by Mr. Phillips[1] in the case of the granites. The inclusions in the rock now under consideration agree with those described by Mr. Phillips, (1) in form; (2) in being more basic in composition than the main mass of the rock; and (3) in the fact that large crystals sometimes project from the inclusion into the ground-mass.

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[1] "On Concretionary Patches and Fragments of other Rocks contained in Granite," Q.J.G.S. vol. xxxvi. p. 1; and "Additional Note on Certain Inclusions in Granite," Q.J.G.S. vol. xxxviii. p. 216.

The following analyses will give some idea of the variation in the chemical composition of these rocks.

	I.	II.	III.
SiO_2	63·41	54·09	52·47
Al_2O_3	16·92	15·02	12·15
Fe_2O_3	2·67	4·12	3·47
FeO	2·96	5·15	5·23
CaO	4·32	7·72	9·71
MgO	2·08	7·28	9·94
Na_2O	5·18	1·99	2·81
K_2O	2·36	3·55	2·26
H_2O	·64 Ig.	1·49	1·62
CO_2		—	·54
	100·54	100·39	100·20

I. Hornblende-porphyrite, intrusive in quartzite, base of Beinn an Fhurain.
II. Porphyritic-diorite, base of Beinn an Fhurain.
III. Plagioclase-pyroxene-hornblende rock, near Inchnadampf, intrusive in limestone.

Titanic acid, phosphoric acid, and manganese are present in the above rocks, but have not been determined. They have therefore been weighed with SiO_2, Al_2O_3, and Fe_2O_3. Specimen I. contains two generations of felspar, and is a typical porphyritic rock. Specimen II. contains only one generation of felspars. The hornblende is more abundant than in I., and sometimes occurs in good-sized porphyritic crystals. Specimen III. differs from the others in containing a large amount of colourless pyroxene.

It is seen to be richer in lime and magnesia, but not richer in iron. In all probability the pyroxene is a nearly pure lime-magnesia bisilicate, and one is tempted therefore to ask whether it may not be due to the absorption by the igneous magma of à certain amount of the dolomitic limestone into which the rock has been intruded. The sporadic manner in which the pyroxene occurs is in favour of the view here suggested. As telling somewhat against this view we have to mention the frequent occurrence of a colourless pyroxene in the more basic plagioclase-hornblende rocks, as, for example, in some of Prof. Bonney's hornblende-picrites[1] and the allied rocks of Warwickshire described by Mr. Allport as diorites.[2]

One very interesting feature which a comparison of the different varieties of diorite brings out is the variation in the state of crystallization in the ground-mass. In the compact rocks the individual felspars are minute, and give more or less lath-shaped sections. It is impossible to determine the precise character of the original ground-mass in consequence of alteration, but it evidently approximated to that of the hornblende andesites. In the medium-grained rocks the microstructure of the ground-mass is thoroughly granitic. Here then we see a gradation exactly similar to that described by

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[1] On the so-called Diorite of Little Knott, with further remarks on the occurrence of Picrites in Wales, Q. J. G. S. vol. xli. p. 511.

[2] On the Diorite of the Warwickshire Coal-field, Q. J. G. S. vol. xxxv. p. 637.

Messrs. Hague and Iddings[1] as occurring in the diorites and hornblende-andesites of the Washoe district.

A specimen of a fine-grained rock collected by Prof. Judd shows a curious spotted or variolitic structure. The rock is much altered, and it is therefore impossible to ascertain its original character. The spots and the main mass of the rock both contain needle-shaped pseudomorphs after hornblende and a microcrystalline ground-mass. The hornblende-needles are not arranged in any definite manner in relation to the spots; sometimes a needle may be observed with one end in a spot, and the other in the ground-mass of the rock. The external boundaries of the spots are not defined by a sharp line, and where two or more spots coalesce, there is no line of separation between them. Where the spots are best defined, they consist of a central more or less spherical portion, which is rendered nearly opaque by opacite dust, and a marginal portion in which the ground-mass is nearly colourless. The structure appears to be analogous to that of the variolitic diabases.

COMPARISON OF THE ROCKS WITH ALLIED ROCKS OF OTHER DISTRICTS.

The plagioclase-hornblende rocks form a very difficult and somewhat unsatisfactory group. In some, as, for example, the epidiorites of Gümbel, the hornblende is undoubtedly secondary; in others, including the rocks now under consideration, it is certainly original. As the question of the origin of the hornblende is one of the greatest interest in relation to the past history of the rocks themselves and of those portions of the earth's crust of which they form a part, it becomes of importance to separate those in which hornblende is secondary from those in which it is a product of the consolidation of an igneous magma. Mr. Allport[2] has shown that in certain plagioclase-hornblende rocks surrounding the Land's End mass of granite, the hornblende is wholly secondary after augite. Such rocks have therefore no affinities with those now under consideration. The same observer has, however, described certain plagioclase-hornblende rocks (diorites) from Warwickshire,[3] in which the hornblende is mainly original. These rocks have certain points of resemblance with those above referred to. The Warwickshire rocks are, as a rule, much altered; but Mr. Allport was fortunate enough to obtain one specimen from Marston Jabet which was absolutely fresh. It was mainly composed of long prisms of well-formed hornblende set in a crystalline aggregate of plagioclase. This rock, therefore, is closely allied to some of those described in this paper. Another point of resemblance between the Warwickshire rocks and those from Assynt is the occurrence in both of a colourless, or nearly colourless, pyroxene, in association with hornblende. There are, however, some important points of difference. The original hornblende of the Warwickshire rocks is brown, and where it occurs abundantly is in the form of large ophitic plates containing inclusions of lath-shaped felspar. In the Assynt rocks the hornblende is green, and appears in all cases to have preceded the felspar in the order of consolidation. Again, some of the Warwickshire rocks contain numerous pseudomorphs after olivine, whereas no trace of this mineral has been detected in any of those from Assynt. The ophitic character of the hornblende and the presence of olivine both point to the conclusion that some of the Warwickshire rocks are more basic in composition than any yet found in Assynt. Many of the Anglesea "diorites" bear the closest relation to the corresponding rocks from Warwickshire. They consist of brown hornblende often passing into green, a colourless pyroxene, plagioclase and magnetite or ilmenite. By the coming-in of olivine and the dying-out of the felspar, these rocks shade into Professor Bonney's hornblende-picrite. Mr. Tawney[1] has described similar rocks from the Lleyn peninsula, Caernarvonshire, under the name of hornblende-diabase. An interesting little boss of "diorite" occurs on the right-hand side of the footpath leading from Mount Sorrel to Swithland (Leicestershire), and just outside Brazil Wood.

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[1] On the Development of Crystallization in the Igneous Rocks of Washoe, Nevada, Bull. U. S. Geol Survey, No, 17, 1885.

[2] On the Metamorphic Rocks surrounding the Land's End Mass of Granite. Q. J. G. S. vol. xxxii. p. 407.

[3] Q. J. G. S. vol. xxxv. p. 637.

This boss projects through the soil, and measures only a few yards across. It varies considerably in texture, some parts being composed of a medium-grained granular rock, and others containing large hornblende crystals or plates. Prof. Bonney has described the rock of this knoll as follows: "Under the microscope the latter mineral [hornblende] is seen to occur in irregular grains, plate-like in section, pierced and intersected by the plagioclase [ophitic] with a little iron peroxide (? some of it ilmenite). The hornblende with transmitted light is both brown and green in colour, and much of it and of the felspar is still in good condition. Here and there patches of the pale fibrous actinolitic variety occur, associated with a mineral rather like a fibrous variety of serpentine. These last are certainly secondary products, and much resemble a variety common in the altered Cornish gabbros. Most of the larger hornblende is strongly dichroic. Some of the brown variety resembles biotite. One or two pieces indeed appear from their optical properties to be that mineral. There is a little calcite with characteristic cleavage. The plagioclase often shows brilliant colours and characteristic twinning, with occasional indications of a zonal structure."

My slide of rock from the same locality agrees with Prof. Bonney's description, but contains, in addition to the minerals which he has mentioned, a colourless pyroxene. This brings the rock into the closest relation with some of Mr. Allport's diorites from Warwickshire, with the Anglesea "diorites," and with Mr. Tawney's hornblendic-diabases from the Lleyn peninsula. I would suggest that, for convenience of description, we should use a special locality as a means of designating rocks of this kind, and as this appears to be the only variety of diorite which is found in the boss at Brazil Wood, it might be termed the Brazil Wood type of diorite. If we do this, we may then state that diorites of the Brazil Wood type occur in Warwickshire associated with Cambrian strata, and also in Anglesea, the Lleyn Peninsula, and the Lake District. It is worthy of note that in no single instance is a diorite of this type known to be associated with Upper Palæozoic or later strata in Britain. I have a specimen of diorite from Glen Tilt (Perthshire) of the same general type, but can say nothing about its mode of occurrence.

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[1] Woodwardian Laboratory Notes, GEOL. MAG. Decade II. Vol. VII. pp. 212 and 457; also Vol. IX. p. 548.

The differences between diorites of the Brazil Wood type and those from Inchnadampf described in the present paper have already been referred to. The interesting fact of the close relation of these diorites to Prof. Bonney's hornblende-picrites has also been pointed out.

V.—THE BROOKWOOD DEEP-WELL SECTION.

By the Rev. A. IRVING, B.Sc., B.A., F.G.S.

THIS section, which was completed last year, appears of such value and interest to students of the Tertiary strata of the London Basin, that I have thought it worth while to offer a description of it to the readers of the GEOLOGICAL MAGAZINE. Through the courtesy of Dr. Barton, the Governor of the Asylum, I have had free access to the specimens preserved of the various strata passed through, and very careful use of them has been made in the preparation of the tabulated statement which follows; much of the information having been kindly furnished from the engineers who were employed. The Asylum is situated at Knap Hill, about a mile and a quarter from Brookwood Station on the South-Western Railway, and is on the Upper Bagshot Sands. The mouth of the well is in the valley just below, about 140 feet above O. D., and about the same level as that at which the Middle Bagshot Beds occur in the famous Goldsworthy section, which furnished Prof. Prestwich, some forty years ago, with the clue to the succession of the beds of the Bagshot Formation. It is about a mile and a half distant therefrom. The evidence as to the horizon in the Bagshot Series, at which the well commences, is very clear to those who are familiar with the stratigraphy. The widely-extended pebble-bed at the base of the Upper Bagshot Sands occurs here very near the top of the well, and I saw it exposed again at about the same level in an excavation made by the side of the high road which runs along the western side of the Asylum Estate. The same greenish loamy sand was intermingled with the pebbles in both cases. In the ploughed field a stiff yellow loam, such as so commonly occurs above this pebble-bed in the Bagshot area,[1] crops out in the valley where the well is situated. The 'brown sandy bed' which occurs at the top of the section is probably a portion of this, re-constructed by later drift action, and mingled with more sandy materials washed down from the sandy strata situated at higher levels on the slopes of the valley.

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[1] *Vide* Q.J.G.S. for August, 1885, pp. 493 (No. 2 of the Section).

In attempting to classify the Bagshot Beds I have used the grouping adopted in descriptions recently published of other deep-well sections [1] in the Bagshot District (those namely at Wellington College, Farnborough and Mytchett), and for the reasons there given. A comparison of this section with those brings out a very remarkable continuity in the general characters of the Middle and Lower Bagshot Beds, though there is just that amount of variation in details which we should be led to expect from the conditions under which they appear to have been deposited.[2] I have found it by no means easy to draw a line between the Lower Bagshot Beds and the London Clay, for there is no abrupt transition from one to the other, in the description given below; while a careful study of the actual specimens leaves no alternative that I can see to the recognition of a gradual passage upwards from the London Clay to the characteristic Lower Bagshot Sands. The resemblance of what is seen here to what is seen in the specimens from about the same horizon in the Wellington College well-section is very close indeed; and is in striking contrast with the abrupt transition between the two formations which I have observed in sections already described at Aldershot, Wokingham, and Bracknell, on the marginal portions of the area.

The following points in connection with this section (see p. 355) appear to me worthy of note.

1. The apparent gradual passage from the London Clay into the Lower Bagshot Sands, as contrasted with the abrupt transition observable in the Walton section recently described by Mr. Hudleston,[3] and in those on the marginal portions of the Bagshot area to which I have referred above.

2. The remarkable absence of any considerable development of clays, the *entire absence of all record of pebbles*, and the general predominance of quartz sand stained by carbonaceous matter of vegetable origin are characters which the Lower Bagshot beds of this section possess in common with the Lower Bagshot strata of three deep-well sections, of which I have given a fuller account elsewhere,[4] and to which I have referred above.

3. The specimens of the slightly loamy sands which occur in this section between the depths of 68 and 143 feet bear a striking resemblance to those which occupy about 92 feet of the Lower Bagshots in the section at Wellington College. This resemblance comes out very strongly when the specimens from the two places are directly compared.

4. Of the *pyrites* found in the Bagshot Sands one large heavy specimen (found at the depth of 130 feet) and many smaller ones are preserved. They are quite unweathered, and are probably pyritized wood *in situ*; but with the *cement stones* found in the same beds the case is different. They are very much weathered, their

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[1] Q.J.G.S. *loc. cit.*

[2] Cf. Q.J.G.S. *loc. cit.*; also Geol. Mag. Dec. III. Vol. II. p. 25.

[3] Q.J.G.S. April, 1886.

[4] Q.J.G.S. *loc. cit.*

Height above O. D. Level about 140 feet.

	Thickness of Beds in feet.	Depth in feet.	Strata passed through in the Brookwood Deep Well.	
	3	3	Brown sandy bed.	
65 feet of Middle Bagshot Beds.	1	4	Gravel (well-rounded pebbles of flint in greenish sand).	
	5½	9½	Dark sand	Dark grey and black sand, with traces of pyrites and fragments of clay ironstone highly weathered, with sand-grains adhering to the old surfaces.
	1¼	10¾	'Iron band,' or 'rust'	
	¾	11½	Shaly band	
	2¼	13¾	Dark sand	
	3¼	17	'Marly' with sandy veins	
	8	25	'Light marl' (quite a pure pipe-clay in the specimens).	
	1	26	Brown clay (a very stiff clay slightly laminated).	
	4¾	30¾	'Greenish clay.'	
	6¾	37½	Dark brown sand.	
	30½	68	Dark sand with *pyrites* and *cement-stones*.	
105½ feet of Lower Bagshot Beds (inclusive of passage beds).	10	78	Hard dark (carbonaceous) loamy sand (with some black grains).	
	19	97	Lighter grey (carbonaceous) sand (black grains more numerous).	
	5	102	Darkish grey sand (loamy).	
	3½	105½	Grey loose sand (with black grains).	
	3½	109	Light grey sand.	
	11	120	Grey sand (with black grains).	
	23½	143½	Dark grey carbonaceous coherent sand, with pyrites.	
	6½	150	Hard dark shaly sand and clay.	Specimens preserved of a dark grey indurated marl with a very definite fracture.
	1	151	Grey sand.	
	1	152	Dark 'clay.'	
	2½	154½	Nearly black shale with intervening layers of grey sand, inclosing numerous green and black grains.	
	9½	164	Thinly-laminated sandy shale (light grey) with minute black grains and spangles of mica on planes of laminæ.	
	5½	169½	Fine clay and sand	The specimens are similar to those of the bed next above, but rather more sandy.
	2	171½	Clay	
	2	173½	Light grey sand	
371 feet of London Clay with "basement-bed."	169½	343	London clay.	The 'beds of stone' may be regarded as septaria for the most part. The only specimens preserved are what appear to be typical of the clay and the stone-beds respectively. The former is a mass of bluish-grey indurated clay, marly enough to have a pretty definite fracture; the latter, "found in the L. Clay," is simply a portion of an ordinary septarian nodule or 'argillaceous limestone.'[1]
	½	343½	'Bed of stone.'	
	18½	362	London clay.	
	5	367	,, ,, with pyrites.	
	7½	374½	,, ,,	
	½	375	'Bed of stone.'	
	25	400	London clay.	
	½	400½	'Bed of stone.'	
	38	438½	London clay.	
	8½	447	,, ,, with pebbles.	
	3	450	,, ,,	
	10	460	,, ,, (thin sand layers).	
	19	479	,, ,, with pebbles.	
	29	508	,, ,,	
	½	508½	'Bed of stone.'	
	9½	518	London clay.	
	1	519	,, ,, with pebbles.	
	15	534	,, ,,	
	10½	544½	Dark sandy clay (basement-bed of L. clay: no record of pebbles).	
89½ feet of Reading beds.	21½	566	Dark brown mottled clay.	
	1	567	'Bed of Stone.'	
	6½	573½	Red mottled clay (a very characteristic specimen preserved).	
	10	583½	Red sandy clay.	
	7½	591	Fine sand.	
	3	594	Red sandy clay.	
	8	602	Coarse brown red sand (very ferruginous, with black and olive-green grains).	
	22	624	Red mottled clay, interbedded with dark grey sand, with traces of pyrites and numerous green grains.	
	10	634	Loose grey sand of the same description as in the bed above.	
	250	884	Chalk with flints. The specimens of flints preserved from the chalk are of the usual colour of native flint from that formation.	

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[1] Cf. Etheridge, Manual of Geology and Palæontology, pp. 609, 610.

calcareous material seems to have been entirely dissolved away, and their surfaces are coated with a layer of coarse sand-grains, as if they had rolled about in sand when softened at their surfaces by water. They present a very different appearance to that presented by the specimens found *in situ* in the London Clay. These Bagshot cement-stones may therefore be considered as *derived in all probability from the London Clay itself.*

5. The least thickness we can assign to the London Clay in this section is 371 feet, not including the passage beds at the top. In the paper referred to above[1] I have drawn attention to the greater thickness of the London Clay in these deep-well sections of the more central portions of the main mass of the Bagshot Sands, as compared with the thickness of the London Clay *beneath the Bagshot Sands*, nearer the north and south margins (*e.g.* in the Aldershot Town Well and the Wokingham Well). This difference of course might arise either (1) from attenuation of the London Clay owing to the conditions of original deposition, or (2) to destruction of the upper beds of the London Clay by denudation during the earlier and middle portions of the Bagshot period. The strong evidence we have now in at least two of the more central well-sections of a passage from the London Clay into the Bagshot beds above, goes to show that deposition was continuous in the central portions of the area; while the abrupt transition from the one formation to the other and the frequent erosion of the London Clay surface beneath Bagshot Beds observable in sections on the northern and southern margins point to the obvious conclusion that the London Clay was there at the same time undergoing destruction by denuding agencies. If this be admitted, it is hardly necessary to point the inference that a slight synclinal curvature was given to the London Clay during the earlier portions of the Bagshot period. But this is not all. This Brookwood section is the first, so far as I am aware, to throw some light upon the *horizons* occupied by the 270 feet of London Clay penetrated in the deep well at Wokingham. A reference to the table of strata given by Prof. Rupert Jones, F.R.S., for the Wokingham Well,[1] and comparison of it with the London Clay strata penetrated in this Brookwood section, brings out a remarkable correspondence (in the occurrence of layers of *septaria*, of *pebbles*, and of *pyrites*) between the 273 feet of London Clay at Wokingham and the *lower* 200 feet or rather more of the London Clay in the Brookwood section; while from the *upper* 150 feet or so of the London Clay in the latter section there is no record of such occurrences. So close is the correspondence here cited that there is only a difference of a foot or so in the distance of one of the layers of pebbles in the two sections above the base of the London Clay. These observations harmonize too with the well-known fact that the London Clay becomes more arenaceous, and has a less pronounced marine character in its upper beds, where shown in its full normal development.[2] Of the two alternatives suggested above, we are surely justified, in the light of this new evidence, in preferring the denudation to the original attenuation explanation of the facts, and

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[1] Q.J.G.S. *loc. cit.*

[2] Cf. Etheridge, *loc. cit.*

can hardly escape a conclusion favourable to the notion of a certain amount of unconformity between the two formations, along the north and south flanks of the area. The occurrence of sharks' teeth, septaria, and flint pebbles in the London Clay at Aldershot, where I have seen them dug out of the stiff blue London Clay only a few yards below the Bagshot Sands of that section, is also in favour of the assignment of the less than 200 feet of London Clay of that district to the *lower* portions of that formation. In a future paper I shall show that the unconformity inferred from the above evidence can be established from a wider induction.

VI.—THE BOIS DE FONTAINE METEORITE, AND ITS PROBABLE IDENTITY WITH THAT OF CHARSONVILLE OF 1810.

By JAMES R. GREGORY.

A FEW years since I received from a correspondent in Paris several fragments of a meteorite, which my informant stated fell at Bois de Fontaine on the estate of the Marquis de la Touane, near Mung, in the department of Loiret, France, in 1825, but no precise date was given. It was said to be unknown and undescribed. My informant also stated that it was presented to the physician of the Marquis de la Touane, from whom he, my informant, received it in exchange. Of the specimens that I received, two had some of the original crust on them, one a small fragment only, and the other a specimen of 254 grammes, but with only a small amount of crust. I had also five or six other specimens without the crust.

On recently referring to the very detailed accounts of some of the falls of meteorites in the early part of this century in the "Mémoire Historique et Physique sur les Chutes de Pierres," by M. P. M. S. Bigot de Morogue, published at Orleans in 1812, I find a very precise description of the fall at Charsonville, as observed by several eye-witnesses; but what excited my curiosity were the same names of persons and of places mentioned in connection with the Charsonville fall, as with that of the Bois de Fontaine. As the data of the so-called Bois de Fontaine was very meagre, and the year of its supposed fall so widely different, I thought that possibly some error had arisen as regards date. I afterwards compared my specimens of the Charsonville, which I have had in my possession some years, in fact long before the Bois de Fontaine was heard of. The British Museum had indeed a specimen from me of the Charsonville stone at the same time I had mine. I found on careful examination with the Bois de Fontaine that they were identical in texture as well as in colour when fresh broken. To be still more certain, Mr. Thomas Davies, of the British Museum, was obliging enough to allow me to compare my Charsonville specimen with the Museum one, and I also compared a specimen of the Bois de Fontaine with the Charsonville at the same time.

It will be seen that it is possible that the physician named by my informant in connection with the Bois de Fontaine stone may be a descendant of the Dr. Pellieux named in the account of the Charson ville fall in 1810; also that I find Meung in the map of the department of Loiret, but not spelt Mung as I had it with the Bois de Fontaine stone, although in M. de Morogue's work it is spelt Meung as in modern maps. In M. de Siemachko's Catalogue, Bois de Fontaine near Beaugency is mentioned, and in M. de Morogue's work it says that Dr. Pellieux resided at Baugenci: this is also probably the same place.

At page 240 of his work Mons. Bigot de Morogue says with regard to the meteorite falls, "The most important which has come to my knowledge is the fall of three stones on the 23rd of November, 1810, in the parish of Charsonville, Canton of Meung, Department of Loiret. At this time I was residing on my estate about six leagues from Charsonville, and a league and a half south of Orleans. Some people attributed it to the explosion of a powder magazine in the direction of Tours; but the true cause did not long remain unknown, for the Baron Pieyre, Prefect of the Department of Loiret, who was as zealous for the progress of science as for the success of his administration, having immediately made inquiry, received a few days afterwards a detailed report from the celebrated physician Dr. Pellieux, residing at Baugenci, a town about two leagues from the place where the stones fell. That report was very interesting, and was accompanied by a fragment of one of the stones, and was read at the Public *Séance* of the Society of Agriculture, Physic, and Medicine of Orleans on November 28, 1810. It was afterwards printed in No. 7 of the report of this learned society, and has been the first public announcement of this event due to a remarkable but nevertheless common phenomenon."

At page 245 of the same work M. Morogue says: "The report of Dr. Pellieux appeared to me to have been written rather hurriedly, and lacked the details which I wished to know; but not being able to go to the place where the stones fell, I wrote to M. de La Touanne, my relative and friend, who was residing at this time on the beautiful estate which bears his name, situate about one league from Charsonville, and begged him to obtain all the details possible on the phenomenon which interested me."

At page 247 he also says: "Monsieur de La Touanne was about one league from the place of the fall, and was walking with his children, when, looking by chance towards the sky in the direction of Charsonville, he heard violent detonations or thunderings, which seemed just over their heads. Forty persons ran from the court of the castle, but they saw nothing. The same evening, however, they heard that some stones had fallen at Charsonville, the fall of which had doubtless caused the noise which had startled them. M. de La Touanne, wishing to verify this fact, went himself the next morning to the place, accompanied by a gamekeeper, a man-servant, and two of his children; arriving at the farm of Villorceau, he was convinced of the truth of the report which he had heard, but no one had either seen the ball of fire or the light. He was told the exact places where the stones had fallen, and he went to examine them himself, and there he picked up some fragments of the stone, one of which he gave me, and he then went himself to visit the holes from which the stones were extracted. He gathered some details from some of those who had been witnesses of the phenomenon, of which one was a carman, a shepherd, and many others who saw the stones fall close to them. He concluded at last all his researches by saying that on the 23rd of November, 1810, at ten minutes past one P.M. there fell three stones in the parish of Charsonville, Canton of Meung, Department of Loiret. Their fall was accompanied by a series of thunderings which lasted several minutes. The stones fell on a space of ground of about half a league, and their fall was perpendicular. The inhabitants perceived neither light nor globe of fire, either immediately above Charsonville, nor in the neighbourhood. One of the stones fell near Mortelle, and was not found;[1] the two others fell at Villeray and at Moulin-brûlé; of these two, one weighed about 20 lbs. and had been found in a hole just large enough to hold it, and about two feet in depth and one foot in calcareous tuff; this hole was vertical, and the stone was removed about half an hour after it fell, being then hot enough to cause considerable discomfort to those who held it in their hands. The second stone had made a similar hole in the ground, and had penetrated three feet in depth; its weight before being broken was 40 lbs. It was taken up about eighteen hours after its fall. It seems certain that the smaller stone, while still warm, emitted a strong odour of gunpowder, and that it retained it even in the house to which it was taken, until it was quite cold."

At page 250 he continues: "One can see in No. 362 of the 'British Library,' published in January, 1811, an account of the same phenomenon, which was extracted from a letter which Madame de La Touanne had written to her mother, and of which some copies had been by chance circulated through Orleans."

In conclusion I think from this account that it may be taken for a fact that the Charsonville and the Bois de Fontaine meteorites are certainly of the same fall, though there is a probability of the Bois de Fontaine stone being the one that at the time of the fall was not found, and which was described as having fallen at Mortelle by M. de La Touanne. It would, therefore, be interesting to know if those museums and collections possessing specimens of both these stones would carefully compare them in order to ascertain if any similarity exists in their specimens, which might help to prove the identity, and of which myself I have little doubt.

VII.—ON THE GEOLOGICAL HISTORY OF THE CORNISH SERPENTINOUS ROCKS.

By J. H. COLLINS, F.G.S.

(*Continued from* Vol. II. p. 298.)

MY argument that at Porthalla there is a "passage" from hornblende-schist to serpentine; or rather that some beds of a common series have been changed into serpentine, others into hornblende-schist, and others again into a substance of intermediate character, is, I think, much strengthened by the fact that many such "apparent passages" are admitted to exist by all those who have examined the Lizard Coast with any degree of detail. De la Beche's description of that seen near the Lizard Town is as follows, and it would apply equally well to the others. "The hornblende slate," he says, "supports the great mass of the Lizard serpentine with an apparent passage of the one into the other in many places—*an apparent passage somewhat embarrassing*," that is, from his point of view; from mine it is perfectly natural. He goes on to say: "Whatever the cause of this apparent passage may have been, it is very readily seen at Mullion Cove, at Pradanack Point, at the coast west of Lizard Town, and at several places on the east coast between Landewednack and Kennick Cove, more especially under the Balk . . . . and at the remarkable cavern and open cavity named the Frying-Pan, near Cadgwith."[1] At Kynance some of the laminæ of serpentine are not more than one-tenth of an inch in thickness for considerable distances. It would not be easy to explain how such thin plates of molten intrusive matter could be forced between the laminæ of an already consolidated stratified rock for many feet together. Now, although thin films of remarkably pure serpentinous matter are often found deposited from aqueous solution in thin fissures in certain parts of the Lizard district, yet in such cases as those referred to at Kynance I do not think such an explanation will apply, and I see no alternative but to believe that these thin bands consist of altered material originally stratified and forming part of the same series as the containing rocks.

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[1] Query, Was this the stone known as the Bois de Fontaine?—J. R. G.

It seems to me that those who deny the origin of serpentine from certain beds of stratified rock are ready enough to invoke Sir H. De la Beche when his views support theirs. If, on the contrary, they happen to clash with their views, or, which is here the same thing, to support mine, they are very ready to explain away his conclusions.

The popular idea that the Lizard Peninsula is composed almost entirely of serpentine or serpentinous rocks is far indeed from the truth. Considerably less than half the area is so coloured on the Geological Survey Map, and there is good reason to doubt whether the whole of this is actually serpentine. Inland, the excavations are few and far between; on the coasts, many of the cliffs are inaccessible; and it may very well be that large areas of hornblende-schist, mica-schist, gabbro, or even of ordinary clay-slate exist, within the area hitherto regarded as wholly serpentinous, the tendency having been hitherto to mark as serpentine whatever is covered by a soil containing fragments of that rock.

II. The Extra-Lizard Serpentines.

Whatever may have been the origin of the Lizard serpentines, it is certain that serpentinous change in the West of England is not confined to the Lizard District. Serpentinous rocks exist in many other parts of Cornwall and Devon; and probably the total area of what may be called the "Extra-Lizard" serpentines is not less than that of the serpentines of the Lizard Peninsula. Some of these rocks have been described by various writers, and in considerable detail; but the descriptions not being generally known, as are those of the Lizard, I refer to them here a little more in detail.

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[1] Report on Cornwall, etc. See also Memoirs of the Geological Survey.

A large proportion of the Extra-Lizard serpentinous masses seem to have been at one time essentially hornblendic rocks. I do not say *originally* hornblendic, but the production of hornblende has preceded that of serpentine. Some, too, appear to have contained considerable proportions of olivine, but this mineral does not, so far as I am aware, exist in them in an unchanged state.

Some writers draw a notable distinction between *serpentine* rocks and those which are merely *serpentinous.* This is no doubt a convenient distinction in some instances; yet it will be often difficult to define the limits of this distinction, since there is no radical difference. On the one hand, there is no such thing as a rock-mass of pure serpentine; while, on the other hand, all serpentinous rocks, whether approximately pure, porphyritic from the presence of unaltered or only partially altered crystals of foreign matter, or contaminated by streaks and patches of foreign substance, are altered rocks, and the serpentine present, whether much or little, is admittedly an alteration product. To avoid naming such rock-masses serpentine, as that of Duporth for instance, it has been proposed to class them with picrite, but I cannot see that much is gained by this. Some portions of this rock, it is true—from the presence originally of a great many crystals of felspar, now mostly kaolinized—are indeed highly aluminous; but other parts contain very few such crystals, and consequently the alumina sinks to an insignificant amount. But, whatever the amount, the basis of the rock is plainly and distinctly serpentine, and even very pure serpentine; and to call it a picrite, apart from the objections to the use of this term as a rock-name owing to its indefiniteness, seems to me not merely undesirable, but even somewhat misleading, if it be understood to beg the question as to the nature of the original rock. Certainly there is neither olivine nor diallage present now, and it is by no means certain that the rock ever contained either.[1]

I will now proceed to give some brief particulars of the various masses of rock outside the Lizard Peninsula, but within the mining region of Cornwall and West Devon, which exhibit a high degree of serpentinous change.

1. *Veryan*[2] (*Gerrans Bay*).—The serpentinous rock at Veryan is a narrow band of dark green colour, which is associated with well-marked gabbro similar to the rocks which form a great part of the

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[1] I do not find picrite mentioned in my edition of Von Cotta. Dana says (p. 258), Picryte from Moravia "consists half of chrysolite (olivine) along with felspar, diallage, hornblende and magnetite." Rutley defines it (Study of Rocks, p. 265) as "blackish-green crystalline rock with a compact black matrix containing porphyritic crystals and grains of olivine. The matrix may consist of hornblende, diallage, or biotite, associated with magnetite and calc-spar. The olivine constitutes nearly half the bulk of the rock." Prof. Bonney regards it as a compound of olivine, a small variable amount of felspar, such as anorthite or labradorite, enstatite or a pyroxenic mineral with biotite.

[2] This district was surveyed by Mr. N. Whitley, of Truro, in 1841, and described in the Report of the Royal Institution of Cornwall. The serpentine was also described by the Rev. Canon Rogers in the Trans. Royal Geol. Soc. of Cornwall, vol. vi. p. 41, 1846.

parish of St. Keverne. It comes in as a wedge between the dark hornblendic "greenstones" of the Nare Head and the Lower Silurian slates and quartzites of the same locality. The excavations upon this band are now mostly filled in, and it is greatly decomposed where it reaches the sea in Gerrans Bay, and appears only as a soft ferruginous mass, so that it is almost impossible to determine whether it is simply an altered bed or occurs as an intrusive mass. For reasons which I need not now specify, I incline to the latter opinion, yet it is worthy of remark, as pointed out by Canon Rogers, that the strike of the band lies in a straight line with that of the serpentine of Porthalla, in the parish of St. Keverne, which is distant some 15 miles to the south-west, and this is at least suggestive of a common origin. However this may be, the serpentines of these two localities are extremely different; the Veryan rock more resembling the ordinary Lizard serpentine than does that of Porthalla. It has no cleavage, but breaks with a splintery fracture like ordinary serpentine. In the mass it is slightly magnetic. Under the microscope, using a 2-inch power, it is seen to consist of a transparent green base, which incloses and surrounds many large much-fractured crystalline masses, not definite crystals, which may be altered olivine. No calcite is visible, but in some places numerous fibres of asbestos may be seen. Throughout the serpentinous ground-mass are sprinkled numerous dark patches of ferruginous matter, as in the serpentine of Coverack. The base of course is not dichroic, nor are the crystalline patches; but these latter are brilliantly coloured by the use of polarized light, especially the asbestos fibres when both polarizer and analyzer are used. The base changes as one Nicol is rotated from pale yellowish green to black. It is possible that this may be altered picrite or some similar rock; but if so, the metamorphosis is very complete, as it contains only one per cent. of alumina. The following are my analyses of this rock:

	1.	2.
Silica	36·55	36·05
Alumina	1·00	·95
Ferric Oxide	8·75	8·00
Ferrous Oxide	2·25	1·00
Chromic Oxide	trace	trace
Lime	trace	trace
Magnesia	32·79	33·79
Alkalies	5·12	4·89
Water (by ignition)	14·59	12·39
	101·05	97·07

I have observed thin layers of serpentinous matter in the joints and fissures of the hornblendic "greenstone" of the Nare Head, where it comes in contact with this serpentine, but I have not sufficiently examined this latter to be able to say whether it exhibits evidence of serpentinous change in itself, or whether these thin films have been merely deposited from water percolating through the rock.

Duporth.—This serpentinous rock has been analyzed and described by Mr. J. A. Phillips[1] and by myself.[2] It seems to form the eastern termination of a dyke of hornblendic greenstone which extends from near the ancient earthwork called Trethullan Castle, in the parish of St. Mewan (near St. Austell), to the sea near Duporth, a distance of over four miles. The typical greenstone in the St. Mewan quarries often contains asbestos and thin layers of serpentine in its joints, and an examination of this intrusive mass in different parts of its course shows that it becomes more coarsely crystalline and porphyritic as it approaches the cliffs, and that the chemical composition is also changed, until finally the hornblendic rock of St. Mewan becomes a serpentine at Duporth.

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[1] Phil. Mag. Feb. 1871.

[2] Min. Mag. Nov. 1877.

The less decomposed portions near the sea-level are seen to consist of serpentine of a darker green colour, full of greyish-white spots of a substance resembling kaolin, which on examination appear to be pseudomorphs of hornblende and perhaps felspar, varying from $\frac{1}{30}$ to $\frac{1}{4}$ of an inch in length. The crystals have not quite lost their power of depolarizing polarized light, but the difference between the crystals and the green base in this respect is not extremely great.

The green serpentine base is often somewhat fibrous, the fibres curving round the larger crystals and exhibiting brilliant colours with polarized light; it is sprinkled with very small prisms of scarcely altered felspar. The base and the altered included crystals are both sprinkled pretty thickly with crystals and grains of oxide of iron, and the whole rock is in places stained yellow or brown with per-oxide of iron.

The following analyses show the interesting changes of chemical composition exhibited in this mass in different parts of its course. (*a*) is the mean of three analyses of the rock at St. Mewan made by Mr. Phillips,[1] (*b*) is my own analysis of the rock from the quarry near Gewans, (*c*) my analysis of the rock at Duporth, and (*d*) a recent analysis of the same rock made by Mr. J. Arthur Phillips.[2] (*e*) is a partial analysis of a selected sample which is more free from included crystals and from oxides of iron than ordinarily.

	a.	*b.*	*c.*	*d.*	*e.*
Sp. Gr.	2·27	2·86	2·64	2·86	
Water	·80	·80	8·65	·72 9·29	11·5
Silica	47·57	50·24	37·09	35·74	38·0
Titanic Acid	trace	trace	trace	—	—
Phosphoric Acid	·12	·20	·21	·18	—
Alumina	17·16	19·19	19·90	12·23	4·3
Ferric Oxide	13·04	15·30	15·54	4·68	8·8
Ferrous Oxide	9·30		2·02	13·84	
Oxide of Manganese	trace	trace	trace	·98	—
Sulphur	trace	trace	—	—	—
Lime	4·11	5·02	trace	trace	—
Magnesia	trace	·93	15·90	22·13	29·2
Potash	2·30	7·21	trace	trace	—
Soda	5·45			·25	—
	99·85	98·89	99·31	100·04	91·08

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[1] Phil. Mag. Feb. 1871.

[2] For this analysis, which was given in the Mineralogical Magazine, *loc. cit.*, I am indebted to Mr. Phillips. He remarks, "I find more magnesia than you do, but

From these analyses it appears that the change is not great at Gewans as compared with St. Mewan, a distance of a mile and a half, and that it consists chiefly in a lessening of the proportions of iron oxides and a slight increase in the silica. Within the next mile, however, a very notable change takes place, the silica being reduced by upwards of 12 per cent., and the alkalies entirely carried off, while the proportion of water increases from less than one to over eight per cent., and the magnesia from less than one to nearly sixteen per cent., or in Mr. Phillips' specimen over 22 per cent. Chemically and mineralogically the rock now consists essentially of something over 30 per cent. of serpentine as a base or ground-mass, containing in crystals and grains nearly 50 per cent. of kaolin, and nearly 20 per cent. of peroxide and magnetic oxide of iron, while in *e* it is a fairly pure serpentine.

I must refer to the paper above mentioned for illustrative drawings of the microscopic structure of the rock. Prof. Bonney considers that from the high proportion of alumina present in this rock, it ought not to be classed with the serpentines; in his Presidential Address to the Geological Society he says of it, "The serpentinous rock of Duporth . . . . appears to be a member of the picrite group. Many of the picrites certainly hang on very closely to the dolerite group, and can be seen to graduate into representatives of it;" but the analyses given above will show that this is an accidental rather than a characteristic component, arising from the distinctly imbedded crystals, and that, in the portions of the rock where these crystals are more sparsely distributed, it approaches in composition an ordinary serpentine rock (which is usually a very different thing to the mineral serpentine).

I have said above why I think this rock should not be classed as picrite. It does indeed seem to have been originally a dolerite, but there is no proof that any considerable proportion of olivine was ever present. The first alteration of the augite seems to have been its conversion into hornblende, and this has subsequently been altered to serpentine.

As to the cause of this remarkable change of a hornblendic into a serpentinous rock, I may remark that the district is one of very extensive disturbance, traversed in all directions by mineral lodes and elvan courses; and it is not more than two miles from the St. Austell granite. I have elsewhere[1] given my reasons in detail for believing that the extensive kaolinization of the felspar of that granite has been produced by mineral solutions acting through fissures from below. I have little doubt that this production of serpentine is due to a similar action, and probably fluoride of magnesia was the principal cause of this alteration, both of the hornblendic base and of the felspathic crystals.

Clicker Tor, near Liskeard.—This remarkable intrusive serpen-

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my specimens have undergone more extensive change than yours, as you will see from the fragment which I inclose." He also observes, "My recent analysis of some remarkably fresh rock from the Sanctuaries gave 1·75 per cent. of magnesia."

[1] The Hensbarrow Granite District, 1876.

tinous mass, well known to tourists as well as to geologists, has been fully described by Messrs. Allport[1] and J. A. Phillips.[2]

Mr. Allport regards the serpentinous base as being due to the metamorphism of felspar, and this is no doubt the case to some extent, as at Duporth; however, much of it appears to be due to the alteration of hornblende, itself an alteration product of augite.

Mr. Allport describes it as follows:—

"Under the microscope, a thin slice of the intrusive rock exhibits a variegated mass of pale green serpentine and a nearly colourless substance intimately blended together; imbedded in this matrix there are numerous pseudomorphs after olivine, and irregular plates of unaltered augite, together with minute grains of magnetite scattered here and there through the mass. The pseudomorphs after olivine are of two kinds, consisting either of serpentine or the white substance just mentioned; both are highly characteristic; the crystalline forms are perfectly preserved, and they are traversed by veins representing the original cracks so generally formed in this mineral.

"In one slice the augite is also greatly altered, and it is interesting to compare the two pseudomorphs side by side.

"Although the ground-mass of the rock exhibits a confused amorphous appearance both in ordinary and polarized light, we are fortunately not left in doubt as to the nature of at least one of its original constituents. The augite frequently incloses highly characteristic pseudomorphs after felspar; some are completely inclosed, while others are only partially imbedded in it; the mode of occurrence is, in fact, precisely the same as that observed in the altered gabbro of Costorphine Hill, near Edinburgh, and in several Scotch dolerites described by me on a previous occasion.[3] In many cases the unaltered augite has preserved in the most perfect manner the sharp edges and angles of the felspar prisms; and whenever the latter project from the augite, it may be readily seen that both the inclosed and outlying portions have been converted into precisely the same serpentinous substance as that forming the ground-mass. It should also be noted that, in the case of partially-inclosed prisms, only those sides or ends which have impressed their shape on the augite exhibit a crystalline form, the outstanding portion being quite undistinguishable from the surrounding mass.

"As it would evidently be absurd to suppose that originally there was no felspar save that inclosed in the augite, there can be no doubt that the original felspathic matrix has been completely metamorphosed, and that we have in the Menheniot rock a highly-interesting and instructive example of the conversion of an intrusive olivine-dolerite into a mass of imperfectly-formed serpentine."

The following is an analysis of this rock by Mr. Phillips:—

Silica	36·60
Alumina	17·58
Ferric Oxide...	14·98
Ferrous Oxide	4·52

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[1] Quart. Journ. Geol. Soc. 128, Nov. 1876, p. 422.

[2] Phil. Mag. 1871.

[3] Quart. Journ. Geol. Soc. vol. xxx. p. 557.

Chromic Oxide	0·14
Carbonate of Lime	2·77
Lime	5·04
Magnesia	5·97
Soda	0·84
Moisture	10·66
	99·10

Polyfant.—The "potstone" of Polyfant near Launceston has long been known as a very infusible and easily wrought rock, one of the few Cornish rocks suitable for elaborate and highly-finished church decoration, and it has been used for such purposes in most of the churches of the neighbourhood,[1] but I am not aware that the rock has been hitherto described from the point of view of the petrologist.

The quarries are very ancient and much filled in, but as far as can be seen they lie in the strike of the associated slates. To the unaided eye the rock appears as a dark greyish-green slightly talcose mass, in some places spotted brown with peroxide of iron. Its structure is somewhat schistose and at the same time brecciated. Whether it be an intrusive mass or an altered volcanic agglomerate is still somewhat uncertain, but I incline to the latter supposition. Under the microscope, and using the 2-inch power, it exhibits a great many colourless crystalline masses, having two cleavages forming oblique angles, which may be altered diallage or enstatite. They are slightly dichroic, but quite dark with crossed prisms. There are also some nebulous nearly circular or hexagonal patches which occasionally have a green spot or a grain of magnetite in the centre. The ground-mass is green—in some parts dichroic; in others not—it is resolvable under the ¼-inch power into a fibrous mass of asbestiform material, which polarizes strongly using crossed prisms where thin. A great many black square crystals of magnetite are present—also some patches of brown oxide of iron probably resulting from the decomposition of pyrites.

My analysis of the rock—in duplicate—gives the following as its composition:—

		a.	b.
Water given off in dessicator	·94	13·16	13·25
,, by ignition	12·22		
Silica		36·90	34·75
Alumina		11·80	12·42
Ferrous Oxide		3·56	3·50
Ferric Oxide		12·00	9·10
Lime		2·80	4·12
Magnesia		15·03	18·58
Potash		3·64	3·62
Soda		trace	trace
		98·89	99·34

Although there are considerable differences between this composition and that of the Duporth rock, yet if chemical composition alone be taken into account—and *as a whole* there is a good deal of analogy between them. But in the Polyfant rock felspar, whether kaolinized or not, seems to be entirely absent, and this forms a notable distinction. Moreover, a great deal of the serpentinous matter certainly does not resemble highly altered olivine; so that, if there be any rock properly to be classed with the picrites in Cornwall, this is it. It must, too, be admitted that the Duporth rock has a good deal of superficial resemblance to it, although it was originally so very different. The Polyfant stone is quite soft—except for the occurrence of occasional hard grains of pyritous or siliceous matter—so that it can be readily cut with a chisel or even with a pocket-knife. Sound fragments have been formed into crucibles and used for melting tin and copper for small castings. It appears to be well adapted for this purpose, although I am unable to say that it has advantage over the ordinary "black-lead" pots.

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[1] A shallow basin or crucible of this rock has been recently found in close juxtaposition with a "celt mould" of hard sandy slate at Altarnum, a few miles from the Polyfant quarries. It was probably used for melting the bronze used by the ancient Britons. It is now in the Museum of the Royal Institution of Cornwall at Truro.

NOTICES OF MEMOIRS.

I.—Short Notices of Scientific Papers.

1.—Iattagelser öfver qvartära bildningar på Gotland. Af Henrik Munthe. Geol. Föreningens i Stockholm Förhandlingar. No. 100. Bd. viii. H. 2.

2.—Om postglaciala sänkningar af Gotland. Af. G. Lindström. id. No. 102, Bd. viii. H. 4.

THE first of these papers contains many interesting facts respecting the Glacial and Post-Glacial phenomena of the isle of Gotland. Two systems of Glacial striæ have been noted, one, best developed in the north and north-west, has a main direction from N.W. to S.E., and the other, extending over the rest of the island, runs from N.E. to S.W. Raised beaches are traced at various elevations up to 78·5 m. or 259 feet above the sea-level, the highest point on the island. A description is given of a remarkable Ås or Kame near Visby, which rests on Boulder-clay, and is partially covered by it. The erratic boulders are traced from the Aland isles, Angermanland; possibly from the South-west of Finland, and from the bed of the Baltic. Two maps are appended; one showing the direction of the striæ and the contour-lines of the island, and the other of the district round Visby.

In the second paper, Prof. Lindström gives a description of sections lately exposed at Hafdhem in Gotland, in which turf deposits, nearly 50 feet above the sea-level, containing 28 species of existing freshwater mollusca, are overlaid by a marine sand with littoral shells. The author points out certain facts in the configuration and structure of the rock terraces in Gotland which indicate that the island received its present form by denudation, previous to the Glacial Period, and that various changes of level have taken place since that time.

3.—Om Kambriska pyramidalstenar. Af A. G. Nathorst. Ofversigt af Kongl. Vetens.-Akad. Förhandl. 1885. No. 10.

4.—Sur les causes de la production de facettes sur les quartzites des alluvions pliocènes de la vallée du Rhône, par M. F. Fontannes. Bull. de la Soc. Geol. de France, t. xiv. 1885-6, p. 246.

Dr. Nathorst notices the various opinions held by German and Scandinavian geologists respecting the origin of pebbles with distinctly facetted surfaces, and he points out that, before they had been particularly remarked in Europe, attention had been called to them in New Zealand by Mr. Travers,[1] in 1869, and their facetted surfaces had been rightly attributed to the action of wind-driven sand. The author records the interesting fact that pebbles with facetted surfaces, precisely similar to those from New Zealand and elsewhere, had been lately discovered in the Eophyton sandstone of Lugnås, Sweden.

M. Fontannes brings forward, in the paper cited, several objections against the sufficiency of wind-driven sand to produce the facetted surfaces of the quartzitic pebbles found on the slopes of the Rhone valley, and attributes the phenomena to the current action of water and sand.

5.—On the Minute Structure of Stromatopora and its Allies. By Dr. C. Rominger, Proc. Acad. Nat. Sci. Phil. 1886, pp. 29–56.

This paper is a criticism of the joint essay by Prof. Nicholson and Dr. Murie on the structure of *Stromatopora*, which appeared in the Journal of the Linnæan Society in 1879! It is certainly peculiar to read this review on a paper published six years ago, and one wonders what Dr. Rominger has been doing in the interval. He does not even now seem to be aware that one of the authors of the paper, with which he can see so much to disagree, has in the meantime further studied the subject, and has himself considerably altered his previously-expressed views. It seems somewhat presumptuous on Dr. Rominger's part to propose to substitute some names of his own, which he brought forward in an unpublished paper unluckily rejected by the Smithsonian Institution, for those given by the authors of the paper he criticizes.

6:—Review of the Progress of North American Invertebrate Palæontology for 1885. By J. B. Marcou. American Naturalist Extra, June, 1886, p. 505.

This paper gives a list and a short précis of the various works which have appeared on the subject. The author remarks that there is a distinct increase in the number of articles on palæontology, and that the tendency to publish new species without any illustrations is also diminishing.

7.—A List of the Cretaceous Foraminifera of Keady Hill, County Derry. By Joseph Wright, F.G.S. Proc. Belfast Nat. Field Club Appendix, 1885, p. 327.

Mr. Wright published in 1874 a list of the Cretaceous Microzoa of Ireland obtained from the material in the interior of flints, and the present paper contains a list of 94 species and varieties of foraminifera from the base of the White Chalk at Keady Hill. Twenty-seven of these are additions to the Cretaceous Fauna of

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[1] See also a paper by J. D. Enys, "On Sand-Worn Stones from New Zealand." Quart. Journ. Geol. Soc. vol. 34, 1878, p. 86.

Ireland, and three forms, ***Gaudryina Jonesiana, Bolivina decorata,*** and ***Marginulina Reussiana,*** are new to science. The new forms, as well as some others, are figured in the plate accompanying the memoir.

G. J. H.

REVIEWS.

I.—MONOGRAPH OF THE EARTHQUAKES OF ISCHIA. A MEMOIR DEALING WITH THE SEISMIC DISTURBANCES IN THAT ISLAND FROM REMOTEST TIMES, WITH SPECIAL OBSERVATIONS ON THOSE OF 1881 AND 1883. By H. J. JOHNSTON-LAVIS, M.D., F.G.S., etc., and SOME CALCULATIONS by Rev. Prof. SAMUEL HAUGHTON, M.D., F.R.S. 4to. pp. 112. With numerous Plates and Photographs. (F. Furchheim, Naples; Dulau & Co., London, 1885.)

IN this work Dr. Johnston-Lavis has essayed to do for the recent earthquakes of Ischia that which was so well accomplished for the great Neapolitan earthquake of 1857 by the late Mr. Robert Mallet. In the mathematical portion of the work he has been fortunate in securing the co-operation of Dr. Haughton, who supplied Mr. Mallet with the necessary equations for his work.

The excellent way in which Dr. Johnston-Lavis made use of his opportunities as a resident in the neighbourhood, after the earthquakes of 1881 and 1883, is very well known; and the columns of *Nature* and various newspapers were supplied with detailed accounts of catastrophes from his pen, many of which contain observations of considerable scientific value. But in the present work, he has treated the whole subject in a systematic and comprehensive manner, and has succeeded in producing a book which, like that of Mallet, is of great value both to seismologists and geologists.

After a short introductory chapter, the author devotes six pages to a *résumé* of what is known concerning the geology of Ischia, based on the researches of Scacchi, Fonseca, Vom Rath, Fuchs, and other geologists. Chapters III. and IV. are chiefly historical; the former dealing with the earthquakes and eruptions which have occurred in the island from the earliest historical times down to the present day; while the latter contains a translation of Covelli's interesting account of the Ischian earthquake of February 2nd, 1828. Chapters V. and VI. are occupied with the details of the author's own observations on the effect of the earthquakes of March 4th, 1881, and of July 28th, 1883, respectively. The destructive effects of these great earthquakes are made strikingly apparent to every one, and especially to those who have visited the island, by the series of admirable photographs, taken for the most part by the author himself, and reproduced for the purpose of this work in Turin.

The next three chapters of the book are devoted to a discussion of the nature of the earthquake waves, and of the paths which they followed, and to a determination of the positions of the seismic vertical, the epicentra, and the isoseismals of the two earthquakes; while, from the observations on angles of emergence at various points, conclusions are deduced as to the form of the "focal cavity" and its mean depth from the surface. It is admitted that the data obtained by those observations are too few and imperfect to base absolutely reliable conclusions upon; but the careful plotting upon maps and sections of those measurements which seem most worthy of confidence, points to the conclusion that the centre of the disturbance was the same in both cases, and must be sought on a line less than one mile in length, running nearly north and south beneath Casanenella from near Lacco towards Fontana. The mean depth of the focus was calculated for the earthquake of 1881 as 518·25 metres from the sea-level, and that of 1883 as 528 metres. The author suggests that the seat of disturbance is a vertical fissure, filled with igneous matter, which is gradually extending itself upwards towards the surface.

In a chapter on the phenomena connected with the earthquakes, the author points out that the Ischian earthquakes were accompanied by muffled rumblings, which near the centre were simultaneous with the shock, but which further away from the centre preceded the shock. Dr. Johnson-Lavis' careful investigation of the reported changes in thermal and other springs in the island before the shock led him to the conclusion that these reports were for the most part unworthy of credence; but in the case of a well near Forio, what seems to be satisfactory evidence is adduced in support of the conclusion that shortly before and after the earthquake sudden changes in the qualities of the water took place; and Prof. Palmieri suggests that the well might be in communication with a fumarole, which from time to time exhibited increased activity. Landslips affecting the soft tufaceous masses which cover so large a part of the island are also shown to be a frequent accompaniment of earthquake-shocks, though they also sometimes occur quite independently of seismic disturbances.

In his two final chapters, and in an appendix, the author indulges in some interesting speculations concerning the cause of the earthquakes of Ischia, and he ventures on some suggestions as to the best methods by which their destructive effects may be guarded against or even prevented. If, as he thinks, a fissure on the side of the old volcano of Epomeo is being extended upwards, till at last the disturbances will culminate in a volcanic outburst, producing another parasitical cone on the old volcano, he suggests that a deep bore-hole might serve as a safety-valve to prevent the destructive accumulation of steam. More practical, perhaps, is the suggestion that careful seismic observations with suitable instruments might result in obtaining useful warnings, as well as more exact knowledge of the phenomena. And lastly he points out that not a little may be done, during the rebuilding of the towns, in the selection of sites, the arrangement of the positions and forms of houses, and in the choosing of the materials and designs of their construction, to ward off the terrible dangers which seem to beset them.

In concluding this notice of a very interesting work, we must heartily congratulate its author upon the energy and zeal with which he has performed his self-appointed task, no less than on the character and appearance of the volume in which he has recorded his results.

II.—EARTHQUAKES AND OTHER EARTH-MOVEMENTS. By PROF. JOHN MILNE, F.G.S. With 38 Figures. Vol. LVI. of the International Scientific Series. (Kegan Paul, Trench & Co.)

SINCE Mallet's "First Principles of Observational Seismology," better known as "A Report on the Neapolitan Earthquake of 1857," no book has appeared on this subject comparable in importance to the present volume. This seems indeed to mark a new epoch in the progress of the science, as that book certainly marked a former epoch, which should probably be reckoned the first. A contrast may be drawn between the two. The first is mainly observational, and its observations are made on single great earthquakes; its names are Mallet and Hopkins; its region of research is Italy; and its conception of an earthquake is one or more shocks. The new epoch is experimental as well as observational; and its observations are made on all, even the minutest tremors; Ewing, Gray, Milne, are its names, its classic region is Japan; and it conceives an earthquake as a train of vibrations. Its great advance is due to the introduction of an instrument of exact research, the seismograph properly so called, a seismometer with recording apparatus. All previous means, the author remarks, ought to be classed not as seismometers capable of measuring a disturbance, but as bare seismoscopes indicating only that a disturbance has taken place.

Our volume presents a full view of the present state of knowledge on this obscure and difficult subject. If any person wonder that so complete a treatise can issue from so remote a region, let him remember that from that region come all the latest additions to our information. Much credit is due to Mr. T. Gray for his revision of the proofs. The correctness shows the pains that must have been bestowed. The only serious error we have noticed is in the equations, etc., of p. 211. Here certainly either explanation or correction is needed. Ought not the index of the second power to be affixed to each letter in these equations?

No branch of the study is neglected: all receive attention. Even practical aspects, so often despised by men who suppose themselves scientific, here have a full share of notice. The 'general conclusions' at the end of Chapter VII. give valuable advice to those who have to build a house in a region exposed to such dangers. There is even a suggestion for the use of Earthquake lamps to extinguish themselves in the act of being overthrown. The 'Earthquake coats,' described as having pockets ready filled with provisions as preparation at a moment's notice for spending a night in the air, relieve with a little amusement more serious recommendations. Undoubtedly the most important notes of advice are No. 8: 'Follow one of the two systems for constructing an earthquake-proof building,' and No. 1: 'In choosing a site, find out the localities which are least disturbed.'

The chapters on the 'Distribution in Time' of earthquakes contain much information and some valuable tables. Extremely interesting is an attempt to exhibit graphically the variations of seismic energy for a particular district, that of Kioto, during twelve centuries. It is curious to find not a continuous decrease but a general diminution interrupted by a temporary increase four centuries back. Not much faith, however, can be placed in any conclusions based on mere records of remarkable shocks. We find surely the temperature of a day easier to estimate than the intensity of a shock. Yet how uncertain are we still as to any real alterations in English climate during a like succession of ages.

Far better founded are the discussions as to the relations of earthquake frequency, intensity, or time of occurrence, with seasons, tides, planets, or barometer. Even here, however, negative answers are disappointingly prevalent, and the solitary result to emerge is that their number is greater in winter.

More valuable and far more trustworthy conclusions are obtained under the heading, 'Distribution in Space.' The author's somewhat novel sport of 'Earthquake hunting' (Chap. X.) has already brought to light several facts of the first rank in importance. Such are, the existence of groups with more or less definite boundaries and separate centres of radiation (see p. 191); the significant coincidence of much-shaken regions with lines where continents dip steeply into oceans; and the action of mountain ranges in barring the progress of a shock. More information on this last now celebrated observation is very much to be desired. Some mountain countries (as Switzerland) are often shaken. Do these shocks originate in the mountains, and if so do they extend into the plains? or does each region keep its products to itself? Is there Free Trade in earthquakes there, or Protection? If delicate instruments like Professor Milne's were judiciously placed and regularly observed, we think it probable that much information might be obtained on points of this nature.

Descriptions of these beautiful instruments form a very interesting portion of the book. The account is, however, brief. It enables the reader to see the action of the machines, but does not go very deeply into either fundamental principles, or practical difficulties. For these a student must refer to the various original memoirs. The principle which underlies all these machines alike is that the surface of the earth moves, and that to obtain a true record of its motion, something must be provided which remains unaffected and does not move with the earth. A freely suspended pendulum fails because a motion of its point of attachment soon creates motions of the bob. A slab on rolling spheres fails because impulses to the slab by friction from the balls cannot be avoided. And whereas a beginner would expect a moving point to write records on a plate, the reader will learn that the writing point is arranged to be motionless, while it is the recording plate which moves with the earth. The difficulty of recording vertical motions by any device is so great that one almost disbelieves any measure of success can be obtained. Ingenious means for overcoming these difficulties are described, and students desirous of learning more may consult a paper in vol. xxxix. of the Quarterly Journal of the Geological Society; and the Transactions of the Seismological Society of Japan. Not the least important application of those beautiful instruments has been the observation of artificial earthquakes. Much curious and useful information has thus been obtained. The effects of canals and even ditches in arresting surface vibrations, though to some extent previously known, are here more completely established. A result of the highest scientific importance that seems looming in the possible future is a true measure of the intensity at origin of a disturbance, as is hinted at on page 62. One drawback to the value of these experiments is that they are made solely with disturbances produced by percussion or explosion, while we can hardly doubt that some earthquakes at least, and probably very many, are due to causes which have no resemblance to a blow.

Interesting purely theoretical discussions will be found in various parts of the book. The diagram in Chap. VII. illustrating reflection and interference is clear and instructive, but readers should remember that the energy of a reflected shock is probably greatly diminished from the energy of incidence. The problem of deducing the origin of an earthquake from observations of its time of occurrence at several distinct points receives elegant treatment in Chapter X. All methods described are vitiated theoretically by changes in velocity of propagation (which Prof. Milne himself has shown to exist), and practically, in such cases as our own Colchester Earthquake, by the inexactness of most records of time. When these last can be trusted, it is probable that the theoretical methods will approximate to the true origin, if there be one, with sufficient accuracy for any practical purpose.

A well-known effect, often observed and often commented on, the rotation produced in many objects by the earthquake, is discussed in the chapter on 'Determination of Origins.' Preference is given to an ingenious explanation credited to Mr. Gray. We cannot, however, ourselves see that this is a very essential advance on the explanation given by Mallet. Their common principle is that a resultant impulse which does not pass through the centre of gravity will create in the body rotation, and the point of the new suggestion appears to be that in bodies on rectangular bases, this impulse must in general come from one angle. The explanation is not applicable for circular bases. Both seem insufficient in view of Meldola and White's observation ("East Anglian Earthquake of 1884," p. 206), that chimneys were in general rotated all in the same direction; with which agrees Prof. Milne's own remark on the stones of the Yokohama cemetery. After all, what object is there in trying to dispense with 'vorticose motion'? As we are dealing not with water, but with earth, the only meaning of the phrase is that a vibratory motion is propagated in a direction transverse to the direction of vibration; the transmission, in brief, of a wave of shearing strain. All instruments at present in use only record the motions of a single point, and none of them are able to distinguish between normal vibrations and transversal such as these.

In Chap. III. a lucid but too brief exposition is given of the consequences from snap after tension, slip after shear, and shock after explosion of steam. The question of Cause is again referred to in Chap. XVII., and other notices occur. The accounts of Earth Tremors and Earth Pulsations refer to subjects which ought, one would hope, to lead hereafter towards much completer insight into earth-crust state, but at present they only raise, without gratifying our hopes. The possible connection of these with secular oscillations of land and sea is necessarily dismissed with no more than a reference to the possibility. Materials do not exist for anything fuller.

Readers may from time to time be conscious that what they are reading is somewhat familiar, that they have met with the account or seen the figure in some not very ancient paper, number, or volume. Ample defence, were defence necessary, would be that such a conspectus of knowledge must, from the nature of the case, be largely a compilation. But there is another reason. It was said once: 'None but himself can be his parallel.' Prof. Milne might almost say that none but himself could be his authority. Those most interesting notes on the results of Japanese observations that have from time to time appeared in "Nature," are to a large extent abstracts of papers from the Seismological Society's Journal. Prof. Milne could find scarce any store worth pillaging except the productions of his own creation. E. H. (Camb.).

III.—Contributions to American Palæontology. Vol. i. No. 1. Published by E. O. Ulrich, Cincinnati, 1886. 8vo. pp. 35, pls. 1—3.

According to Mr. Ulrich's experience, the learned societies of America are inadequate to the needs of the Palæontologist, since if they accept papers, they are unable or unwilling to furnish the necessary illustrations, and he therefore intends to make himself independent by bringing out, from time to time, a series of what are styled "private publications," of which the present number is the first.

It contains descriptions of "New Silurian and Devonian Fossils," for the most part Bryozoa. A fresh classification, to replace one brought forward by the author in 1882, is proposed for the families Fenestellidæ and Acanthocladidæ. In the former, three new genera are introduced, but they are left without names; there is no description of any type species; and their essential characters appear to be extremely slight.

Descriptions and figures are given of a number of new species belonging to the genera *Fenestella*, *Semicoscinium*, *Unitrypa*, *Polypora*, *Fistulipora* and *Eridopora* in addition to two new genera, *Buscopora* and *Lichenotrypa*.

The author bases a new genus of Brachiopoda, named *Schizobolus*, on the internal characters of *Discina truncata*, Hall. The generic affinities are stated to "appear to lie between the Obolidæ on the one side and the Discinidæ on the other; the dorsal valve is not unlike that of *Discina*, whilst the whole shell resembles Discinisca, Dall." The author describes the specific characters in detail, but fails to point out those which should mark the proposed genus from its nearest allies.

A new species of *Rhynchonella* is founded on specimens showing casts of the interior, and a new species of *Gypidia* is described. Several new species of *Platyceras*, a new genus of corals, *Bucanophyllum*, and new species of *Strombodes* and *Labechia* are introduced and figured. Finally a new genus of Foraminifera named *Moellerina* is based on some minute orbicular bodies with spiral ridges on the outer surface. It seems to have escaped the notice of the author that these bodies have been already described and figured by Professor Dawson, as *Saccammina* (*Calcisphæra*) *Eriana*, and that they were previously mentioned by Prof. Meek as probably the fruits of *Chara*.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—June 23, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On some Perched Blocks and associated Phenomena." By Prof. T. McKenny Hughes, M.A., F.G.S.

The author described certain groups of boulders which occurred on pedestals of limestone rising from 3 to 18 inches above the level of the surrounding rock. The surfaces of these pedestals were striated in the direction of the main ice-flow of the district, while the surrounding lower rock in no case bore traces of glaciation, but showed what is known as a weathered surface.

He inferred that the pedestals were portions of the rock protected by the overhanging boulder from the down-pouring rain, which had removed the surrounding exposed parts of the surface. When the pedestals attained a certain height relatively to the surrounding rock, the rain would beat in under the boulder, and thus there was a natural limit to their possible height.

He referred to the action of vegetation in assisting the decomposition of the limestone, and considered that there were so many causes of different rates of waste and so many sources of error, that he distrusted any numerical estimate of the time during which the surrounding limestone had been exposed to denudation.

Considering the mode of transport of the boulders, he thought that they could not have been carried by marine currents and coast-ice, as they had all travelled, in the direction of the furrows on the rock below them, from the parent rock on the north. Moreover, marine currents would have destroyed the glaciation of the rock and filled the hollows with débris.

Furthermore, the boulders and striæ are found in the same district at such very different levels and in such positions as to preclude the possibility of their being due to icebergs.

Nor could the boulders represent the remainder of a mass of drift which had been removed by denudation, for the following reasons:—

1. They were all composed of one rock, and that invariably a rock to be found in place close by.

2. Any denudation which could have removed the clay and smaller stones of the drift would have obliterated the traces of glaciation on the surface of the rock.

3. The boulder which had protected the fine glacial markings below it from the action of the rains would certainly in some cases have preserved a portion of the stiff Boulder-clay.

4. The margin of the Boulder-clay along the flanks of Ingleborough was generally marked by lines of swallow-holes, into which the water ran off the Boulder-clay; and when the impervious beds overlying the limestone had been cut back by denudation, a number of lines of swallow-holes marked the successive stages in the process; but there was not such evidence of the former extension of the drift up to the Norber boulders.

5. The boulders themselves were not rounded and glaciated in the same way as the masses of the same rock in the drift, but resembled the pieces now seen broken out by weathering along the outcrop of the rock close by.

Having thus shown the improbability of these boulders having been let down out of a mass of drift the finer part of which had been removed by denudation, or of their having been masses floated to their present position on shore-ice, he offered an explanation of their peculiar position, which he thought was not inconsistent with the view that they belong to some part of the age of land-ice.

That they were to be referred to some exceptional local circumstances seemed clear from the rarity of such glaciated pedestals, while boulders and other traces of glaciation were universal over that part of the country. He therefore pointed out in explanation, that they occurred always where there was a great obstacle in the path of the ice:—at Cunswick the mass of Kendal Fell curving round at the south and across the path of the ice; at Farleton the great limestone escarpment rising abruptly from Crooklands; at Norber the constriction of the Crummack valley near Wharfe and the great mass of Austwich grit running obliquely across its mouth. In all these cases the ice had to force its way up hill; and there would be a time when it would just surmount the obstacle after a season of greater snowfall, and fall back after warm seasons, until it fell back altogether from that part. During the season of recession, boulders would be detached below the ice-foot; during the seasons of advance they would be pushed forward; and in those exceptional localities of isolated hills from which the drainage from higher ground was cut off, the boulders were left on a clean furrowed surface of limestone, which was then acted upon by rain-water and the vegetation, except where protected by the boulders.

2. "On some Derived Fragments in the Longmynd and Newer Archæan Rocks of Shropshire." By Dr. Charles Callaway, F.G.S.

Further evidence was added to that given in the author's previous paper (Q.J.G.S. 1879, p. 661), to show that the Longmynd rocks of Shropshire were chiefly composed of materials derived from the

Uriconian series, and that the Uriconian series itself (Newer Archæan) was partly formed from the waste of pre-existing rocks. This evidence consisted of (1) the presence, throughout the greatly developed Longmynd conglomerates and grits, of purple rhyolite fragments, recognized by microscopical characters as identical with the Uriconian rhyolites of the Wrekin, and the occurrence of grains, probably derived from the same rhyolites, in the typical green slates of the Longmynd; and (2) the existence of conglomerate beds containing rounded fragments of granitoid rock in the core of the Wrekin itself, whilst the Uriconian beds of other localities, and especially those of Charlton Hill, contained waterworn pebbles, chiefly metamorphic. These pebbles appeared to have been derived from metamorphic rocks of three distinct types. The views put forward were founded on microscopical evidence, of which some details were given in the paper, and were supported by the views of Professor Bonney, who had furnished notes on the microscopical characters of the rocks.

3. "Notes on the Relations of the Lincolnshire Carstone." By A. Strahan, Esq., M.A., F.G.S.

The Lincolnshire Carstone has hitherto been supposed to be correlative with the upper part of the Speeton series, and to be quite unconformably overlain by the Red Chalk (Quart. Journ. Geol. Soc. vol. xxvi. p. 326–347). But the overlap of the Carstone by the Red Chalk, which seemed to favour this view, is due to the northerly attenuation, which is shared by nearly all the Secondary rocks of Lincolnshire. Moreover, the Carstone rests on different members of the Tealby group, and presents a strong contrast to them in lithological character, and in being, except for the derived fauna, entirely unfossiliferous. It is composed of such materials as would result from the "washing" of the Tealby beds.

In general it is a reddish-brown grit, made up of small quartz-grains, flakes and spherical grains of iron-oxide, with rolled phosphatic nodules. Towards the south, where it is thick, the nodules are small and sporadic. Northwards, as the Carstone loses in thickness, they increase in size and abundance, so as to form a "coprolite-bed," and have yielded specimens of *Ammonites speetonensis*, *A. plicomphalus*, *Lucina*, etc. When the Carstone finally thins out, the conglomerate character invades the Red Chalk, similar nodules being then found in this rock.

The presence of these nodules, with Neocomian species, taken in connexion with the character of the materials of the Carstone, points to considerable erosion of the Tealby beds. On the other hand, there is a passage from the Carstone up into the Red Chalk. It would seem, then, that the Carstone should be regarded as a "basement-bed" of the Upper Cretaceous rocks.

The Lincolnshire Carstone is probably equivalent to the whole of the Hunstanton Neocomian, the impersistent clay of the latter being a very improbable representative of the Tealby Clay. It therefore follows that the whole Speeton series is absent in Norfolk, and also in Bedfordshire. The unconformity at the base of the Carstone becomes greater southwards, and the nodules have been derived from older rocks. Similarly north of Lincolnshire, where the Speeton series is overlapped, the nodules in the Red Chalk, marking the horizon of the Carstone, have been derived from Oolitic rocks.

In the South of England it would seem that equivalents of the Speeton series reappear. The Atherfield clay contains an indigenous Upper Speeton fauna, while a pebble-bed near the base of the Folkestone beds is described by Mr. Meÿer as containing derived Oolitic pebbles, and being probably the representative of the Upware deposit, and presumably, therefore, also of the Lincolnshire Carstone.

4. "The Geology of Cape-Breton Island, Nova Scotia." By Edwin Gilpin, Esq., Jun., A.M., F.R.S.C., Inspector H.M.'s Mines.

After referring to previously published descriptions of Cape Breton geology, the author stated that the various formations found in the island had been thus classified by the officers of the Geological Survey:—

- Pre-Cambrian (Laurentian) including
  - The Felsite series.
  - The Crystalline Limestone series.
- Lower Silurian,
- Devonian.
- Carboniferous, including
  - Lower Coal-formation.
  - Gypsiferous series.
  - Limestones, etc.
  - Millstone-Grit.
  - Middle Coal-formation.

He then proceeded to give an account of each system and its subdivisions in order, commencing with the most ancient and adding a few detailed sections of the rocks belonging to some of the principal series. He described the distribution and relations of the several divisions.

The paper concluded with a few notes on the superficial geology of the island. There is a general absence of moraines and of the fossiliferous Post-Pliocene marine clays of the Lower St. Lawrence. The older beds are generally exposed, but deeper soils and deposits with erratic boulders are found overlying the Carboniferous beds. Marks of recent ice-action are found on the shores of some of the lakes, and are due to the ice being driven by the wind.

5. "On the Decapod Crustaceans of the Oxford Clay." By James Carter, Esq., F.G.S., etc.

The author commented on the paucity of these fossils as indicated in British lists, only three or four species having hitherto been recorded.

The discovery of considerable numbers of Decapod Crustaceans in the Oxford Clay of St. Ives has enabled the author to increase the list materially. Many have been collected by Mr. George, of Northampton. These fossils occur in the clay immediately beneath the St. Ives rock, and therefore presumably in the uppermost zone of the Oxford Clay. Many of the specimens are more or less mutilated, but some fifteen or sixteen distinct species have been made out. None of these have been recorded as British except *Eryma Babeaui,* mentioned by Mr. Etheridge as having been found in the Kimmeridge Clay. Seven species are identified as foreign forms, and seven are new to science. They are distributed as follows:—

Eryon	1	species.
Eryma	5 or 6	,,
Glyphea	2	,,
Magila	2 or 3	,,
Mecochirus	2	,,
Goniochorus	1	,,
Undetermined	3	,,

Nearly all the forms belong to the type of the Macrura, the Brachyura being doubtfully, if at all, represented.

6. "Some Well-sections in Middlesex." By W. Whitaker, Esq., B.A. Lond., F.G.S.

Accounts of many well-sections and borings having been received since the publication of vol. iv. of the Geol. Survey Memoirs, the author now gave more or less detailed descriptions of fifty-six of these, all in the Metropolitan county, and all either unfinished or, in a few cases, with further information as to published sections. The depths range from 59 to 700 feet, more than half being 300 feet or more deep. Nearly all pass through the Tertiary beds into the Chalk, and most have been carried some way into the latter. Papers descriptive of like sections in Essex, Herts, and Surrey have been sent to Societies in these counties.

7. "On some Cupriferous Shales in the Province of Houpeh, China." By H. M. Becher, Esq., F.G.S.

This communication contained some geological observations made during a visit to a locality on the Yangtse river, near I-chang, about 1000 miles from the sea, for the purpose of examining a spot whence copper-ore (impure oxide with some carbonate and sulphide) had been procured.

The principal formations in the neighbourhood of I-chang were said to be Palæozoic (probably Carboniferous) limestones of great thickness, overlain by brecciated calcareous conglomerate and reddish sandstones, which form low hills in the immediate vicinity of the city. About fifty miles further west the limestones pass under a great shale-series with beds of coal, the relations of which to the sandstones are not clearly ascertained.

The copper-ore examined by the writer came from the shales, which contained films and specks of malachite and chrysocolla, and in places a siliceous band containing cuprite, besides the oxydized minerals, was interstratified in the beds. Occasionally larger masses of pure copper-ore are found imbedded in the strata. The ground had not been sufficiently explored for the value of the deposits to be ascertained.

8. "The Cascade Anthracitic Coal-fields of the Rocky Mountains, Canada." By W. Hamilton Merritt, Esq., F.G.S.

The coal-field named occurs in the most eastern valley of the Rocky Mountains, that of the Bow river, and, like other coal-fields of the country, consists of Cretaceous rocks, which lie in a synclinal trough at an elevation of about 4300 feet above the sea. The underlying beds, of Lower Carboniferous or, possibly, Devonian age, rise into ranges 3000 feet higher.

Further to the eastward the Jurassic and Cretaceous coal contains a large percentage of hygroscopic water and volatile combustible matter, and has the mineral composition of lignite. The average composition is:—

Fixed carbon	42	per cent.
Volatile combustible matter	34	„
Hygroscopic water	16	„
Ash	8	„
	—100	

As the mountains are approached, the amount of hygroscopic water is found to diminish by about one per cent. for every ten miles, and fifteen miles from the range the percentage is about five. In the foot-hills the lignites pass into a true coal, with 1·63 to 6·12 per cent. of hygroscopic water, and 50 to 63 per cent. of fixed carbon. In the Cascade-river Coal-field the average character of the coal is that of a semianthracite, with the following composition:—

Fixed carbon	80·93	per cent.
Volatile combustible matter	10·79	„
Hygroscopic water	·71	„
Ash	7·57	„
	100·00	

The coal-seams have been subjected to great pressure, and the change in the quality of the coal appears to be due to metamorphic influence.

9. "On a new Emydine Chelonian from the Pliocene of India." By R. Lydekker, Esq., B.A., F.G.S.

The author described the shell of an Emydine Tortoise from the Siwaliks of Perim Island, Gulf of Cambay, which he regarded as decidedly distinct from any of the previously-described Siwalik species, and proposed to refer to the genus *Clemmys*, with the name of *C. Watsoni*, in compliment to the donor of the specimen.

10. "On certain Eocene Formations of Western Servia." By Dr. A. B. Griffiths, F.R.S.E., F.C.S. Communicated by the President.

A great thickness of paper-shales containing paraffin occurs near the river Golabara; these extend over 30 square miles of country. Small beds of clay with rock-salt are also found: the whole is said to resemble the paraffin and salt districts of Galicia. The paraffin shale is free from bituminous impurities. It contains:—

Paraffin wax	1·75	per cent.
Water of combination	3·02	„
Ammonia	1·18	„

The mineral constituents of the shale are:—

Alumina	32·86	per cent.
Iron oxide	5·20	„
Magnesia	1·26	„
Lime	1·21	„
Potash	2·17	„
Soda	0·41	„
Silica	56·85	„
Loss	0·04	„
	100·00	

The brown coal of the neighbourhood, whose natural distillation has most probably yielded the hydrocarbon in the shales, contains:—

Carbon	49·2	per cent.
Hydrogen	1·1	,,
Water, combined	30·2	,,
Water, hygroscopic	19·5	,,
	100·00	

The beds containing these coals have been invaded by eruptive porphyry and trachytic rocks, of which the former contains 75½ and the latter 61 per cent. of silica.

The clays from which the shales were originally formed contain abundance of marine Diatomaceæ and Foraminifera (chiefly Nummulites), as also species of *Ostrea*, *Cyrena*, *Cerithium*, *Voluta*, and *Nautilus*, together with the remains of Placoid and Teleostean fishes.

CORRESPONDENCE.

WATER-BEARING NODULES IN THE LOWER GREENSANDS.

Sir,—The brilliant and varied colouring of the Lower Greensands at the Great Northern Railway at Sandy Junction, and at Flitwick Station on the Midland line, must be familar to every one who has travelled those districts. At Sandy, the cutting is a deep one and nearly all in clean sand, varying through shades of green, grey and yellow, the yellow predominating, to almost pure white. At Flitwick, the colouring is still more varied; beautifully tinted bands of a fleshy pink or salmon tint, merging into violet, appear near the bottom of the pit from which Mr. Franklin, of Bedford, obtains his sand. The parti-coloured bands are more numerous at this place than I recollect seeing elsewhere in Bedfordshire, although the white and yellow sand at Heath and Reach, makes very picturesque openings amongst the woods and ferns. The sands at Flitwick remind one of the assemblage of colours met with in the sands,[1] from which the well-known sand pictures are made in the Isle of Wight.

But besides the varied colouring, ironstone nodules, associated with hard lumps of ferruginous rock, like the carstone quarried at Snettisham in Norfolk, are very general in the Greensand. Being of all shapes and sizes and in every stage of growth, they are curious to look upon, and still more interesting to crack for the fossils and sparry crystals that are sometimes found inside them. An abundance of these concretions occurs both at Sandy and Flitwick, some spherical, others tabular, and many other forms.

With Rhodes, the fossil collector, I have lately obtained a number of these nodules from Flitwick,[2] some of which, for description sake, and from the fact of their having water in them, I have designated water-bearing nodules. These are readily distinguished from others inclosing phosphatized fossils (principally the internal casts of some species of oyster), by being audibly full of water when shaken. Many contain only sand, lime or earthy matter, perhaps the residue of fossils destroyed.

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[1] Bagshot Sands.

[2] From the peat at Flitwick I picked out, last year, a small flint implement.

Collecting the water-bearing nodules is somewhat akin to choosing cocoa-nuts at the greengrocer's. We pick up one after the other from the ground, rejecting the light ones, and those that give forth no sound, in favour of those which, like the cocoa-nuts with milk, bear unmistakeable evidence of containing liquid.

What the nature of this liquid may be,[1] or what duration of time has elapsed since it was sealed up in these portable reservoirs, is not for me at present to say, having as yet made no minute examination. The specimens contained water when we picked them up, as did others when split with the hammer. Since bringing them home, they have been in a warm room, and the water from some reason, probably increased temperature, has evaporated or disappeared. The iron pan which forms the walls of the cavity may be porous, and I have placed them in a vessel of water, expecting them to become water-bearing nodules again; the phenomenon would then be probably explained, by supposing that during periods of wet these nodules absorb the water percolating through the Greensand.

It then becomes a question whether these nodules may not be a cause of diminution in the water supply? in districts where they are largely developed. But against the absorption theory, remains the fact that the weather was very warm and fine when the nodules were gathered, and the recent heavy rains had not set in.[2]

A. G. Cameron,
H. M. Geological Survey.

Bedford.

ON THE TERM NEOCOMIAN.

Sir,—In writing his article upon the above subject, in the last Number of the Geological Magazine, my friend Mr. Jukes-Browne appears to have been labouring under a curious and very unfortunate misconception. He says:—

"For many years English geologists were content with the nomenclature employed by the earlier students of the Cretaceous system—Webster, Murchison, Mantell and Fitton. In 1864, however, the French term Neocomian was introduced by Prof. Judd, who adopted it for the Cretaceous portion of the Speeton Clay, and Sir Charles Lyell subsequently used it as a synonym for the whole Lower Cretaceous series in England, as distinct from the Upper Cretaceous series or the beds lying above the Lower Greensand."

Through the whole of the following pages, the writer of the article enlarges upon this text, treating myself as responsible for the error, as he regards it, of introducing the term Neocomian into English geological literature.

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[1] Since writing the above, it has been suggested to me that an analysis of the water might be made. This would of course be a valuable guide to the source of supply.—A. G. C.

[2] For a description of the mode of formation of the ironstone concretions, see Penning, Geol. Mag. Dec. II. Vol. III. p. 218. Geology of Cambridge, Geological Survey Memoir, p. 12, Penning and Jukes-Browne.

Now what are the real facts of the case? For the last forty or fifty years the term Neocomian has been quite commonly applied, by many eminent English geologists, to a part or to the whole of the Lower Greensand, and even those who are prepared to credit me with the most phenomenal precocity, could scarcely charge me with leading astray my fathers in science so long ago as that. The author who had the chief honour, as I esteem it, of introducing the term to English science was the late Mr. R. A. C. Godwin-Austen, and his practice dates at least as far back as the year 1843. If my friend Mr. Jukes-Browne will refer to several memoirs by that author—such as those "On the Geology of the South-East of Surrey" (Proc. Geol. Soc. vol. iv. (1843), pp. 167–173, 196–198); "On the Age and Position of the Fossiliferous Sands and Gravels of Farringdon" (Quart. Journ. Geol. Soc. vol. vi. (1851), pp. 454–478); and "On the Possible Extension of the Coal-measures beneath the South-Eastern part of England" (Quart. Journ. Geol. Soc. vol. xii. (1856), pp. 38–73)—he will find that Mr. Austen not only uniformly employs the term Neocomian for a part at least of the Lower Greensand, but that he defends his practice by some very judicious and cogent arguments. If the writer of the article will look through the contemporary geological literature in this country, he will also find that the example of Mr. Godwin-Austen was followed by other geologists of high reputation.

Of course Mr. Godwin-Austen—who happened to have a remarkably extensive acquaintance with continental geology—was well aware of the fact referred to by Mr. Jukes-Browne, that at Neuchatel there is no exact representative of our Lower Greensand; but Mr. Godwin-Austen's arguments, based on the fact that the fossils of our English formation (or at least of the lower part of it) are very similar to those of the Neocomian, while they are on the whole very different from those of the Upper Cretaceous, have always seemed to me to be worthy of the most careful consideration; and many other geologists, I find, have acknowledged their weight by following his example.

My own part in connection with this question was very different from what my friend supposes; it consisted in describing a series of strata, in Lincolnshire and Yorkshire, which are for the most part older than the Lower Greensand, and correspond in age with strata on the Continent which all geologists, including Mr. Jukes-Browne, agree in calling Neocomian. At the same time, as I have already stated in a paper in this Journal (Geol. Mag. Vol. VII. 1870, p. 220), I have always regarded Mr. Godwin-Austen's proposal to extend the use of the term as originally defined, so as to include the English Lower Greensand, to be much more logical and defensible than that of M. D'Orbigny—which was to restrict the name to one part of the series.

Considering, as I do, the Neocomian to be a great continuous system of strata, with no very important breaks in it, the conventional limits which are to be adopted for the Upper, Middle and Lower divisions, respectively, appear to me to be a question of by no means great importance. At the same time, any attempt to disturb, without very good cause shown, names which have come into general use, or to alter the definition of terms which have been generally accepted—whether the attempt be made by officers of the Geological Survey, in their individual or their corporate capacity—will, I strongly suspect, prove a hopeless, as I am sure that it is a useless, task. Consequently, I trust the idea of "formulating a new nomenclature" as the result of "the revision by the members of the Geological Survey" of the Cretaceous rocks of England, is one that will, in moments of calmer reflection, be abandoned. Scientific names go through a "struggle for existence," and the fittest survive. I trust my friend Mr. Jukes-Browne will draw a moral from the fact, that the name Neocomian has shown a very considerably greater vitality than he seems to have suspected.

But while Mr. Jukes-Browne gives me credit for that of which I cannot possibly accept the honour, he himself assumes a responsibility which, it seems to me, he is not called upon to bear. In speaking of "the merits of the name (*Vectian*) which I have already proposed as a substitute for Lower Greensand," he must surely have forgotten a well-known passage in the works of Dr. Fitton. After remarking that he had long since stated his objections to the use of the term Lower Greensand, that author writes as follows:—"If hereafter a change be thought desirable, he conceives that the new denomination should be taken from the *Isle of Wight*, where this portion of the sub-cretaceous groups was first distinguished, and where the sections on the coast are remarkable for their distinctness; and if such a case should arise, he suggests the name *Vectine* for the strata now called Lower Green Sand, from the ancient name of that island,—*Insula Vectis* of the Romans" (Quart. Journ. Geol. Soc. 1845, vol. i. p. 189).

As the paper in which this passage occurs was read in 1844 and published in 1845, it seems to me scarcely more likely that Mr. Jukes-Browne could have offered useful hints on the subject to Fitton than that I was engaged in a previous year in improperly influencing Godwin-Austen. JOHN W. JUDD.

ERUPTION OF MOUNT TARAWERA, NORTH ISLAND, NEW ZEALAND.—A most destructive volcanic outburst occurred on the night of the 9th of June, from Tarawera, a mountain not more than 3000 feet high, which rises near the lake of the same name, and about nine miles from Rotomahana. At two o'clock a shock of greater violence occurred followed by a terrific roar, a pillar of light shot up from the summit of Tarawera, molten lava and hot mud were rained abroad, while huge rocks were thrown up and around in all directions. Showers of hot cinders and boiling mud covered the settlement of Wairoa, killing on the spot or burying alive numbers of persons. For sixty miles the destruction has spread. About 100 persons have perished, whilst villages and settlements are covered with eight or ten feet of mud or ashes. We hope to give a fuller account in our next number.

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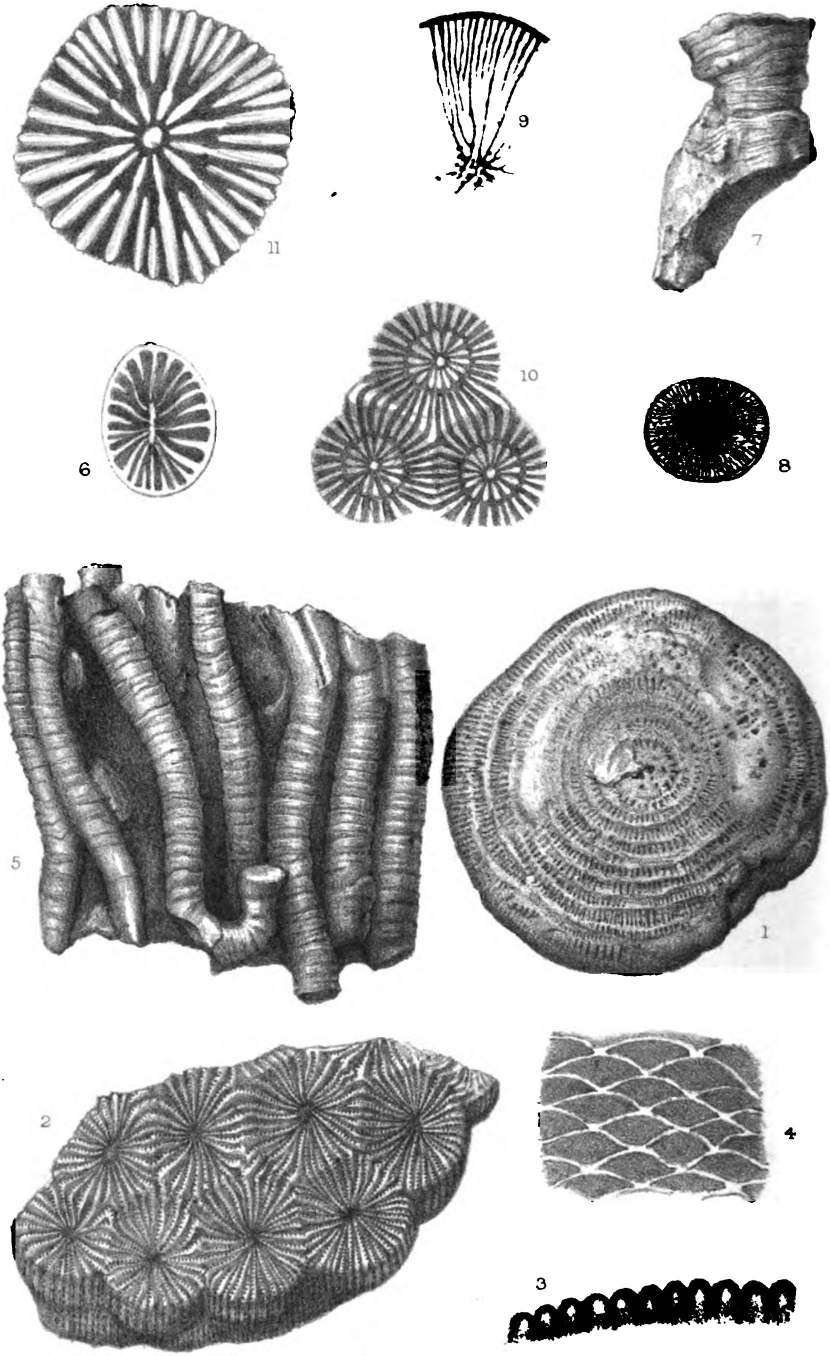

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To illustrate Mr Tomes's paper.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. III.

No. IX.—SEPTEMBER, 1886.

ORIGINAL ARTICLES.

◆

I.—On Some New or Imperfectly Known Madreporaria from the Inferior Oolite of Oxfordshire, Gloucestershire and Dorsetshire.

By Robert F. Tomes, Esq.

(PLATE X.)

IN the thirty-eighth volume of the Quarterly Journal of the Geological Society is a paper by me on the Corals of the Inferior Oolite, and in the following volume is one on the Corals of the Great Oolite. The forty-first volume of the same periodical contains a supplement to the latter, but to the former no such addition has yet been made. The present communication makes good that deficiency, and is a supplement to it. It contains, besides the description of some new species, additional remarks on others already known, mention of genera about which doubt has been expressed, and the description of one which I consider new. Another genus, *Stephanocœnia*, though well known elsewhere, has up to the present time remained unrecognized as British, and is now introduced on the evidence of two well-marked species from the Inferior Oolite of Gloucestershire. The addition to our Coral fauna of such genera as the above, and of others equally well known which I have also had the opportunity of making known, is of even greater interest than the discovery of new genera and species. *Epismilia, Donacosmilia, Cyathophyllia, Adelastræa, Stylosmilia, Rhizangia, Thecoseris, Leptophyllia,* and *Enallohelia*, form a valuable contribution towards the Coral fauna of this country.

Three papers on Fossil Madreporaria have lately appeared from the pen of Professor Duncan, two of which are professedly criticisms on my own communications on the same subject. The title of the first is, "On the Astrocœniæ of the Sutton Stone and other Deposits of the Infra Lias of South Wales."

That of the second is, "On the Structure and Classificatory Position of some Madreporaria from the Secondary Strata of England and South Wales." Both these were read at the meeting of the Geological Society on the 4th November, 1885, and appeared in full in the Journal of the 1st of February, 1886. The third paper appears in the February Number of the Geological Magazine for the present year.

Of the first of these I have only at present to say that it is deserving of consideration, because it is based on the examination of authentic specimens, though whether the conclusions sought to be maintained are substantiated is yet open to question. The purpose of the paper is to re-assert what I have objected to, namely, that the distant and cylindrical corallites of such compound and compact corals from the Sutton Stone and neighbouring conglomerates as have columellæ have become cylindrical by matter added to the walls themselves, and not by the interposition of true cœnenchyma, as in *Stylina* and other allied genera. To this I shall refer on some future occasion. Professor Duncan's third paper is an answer to one of mine on some Cretaceous Madreporaria, and the consideration of it may also remain over until another opportunity. But the second paper, as it relates principally to Oolitic genera and species, may be here discussed. I have not, however, the remotest intention of entering into a controversy on the many points on which Professor Duncan and I entertain opposite opinions. Controversy, when carried to the length it sometimes is, embarrasses the editor, is offensive to the reader, and lowers the tone of the periodical in which it appears—a consummation much to be regretted. With every wish, however, to avoid such an occurrence, I must claim the privilege of making known the conclusions to which my investigations have brought me, and of re-asserting or modifying from time to time, if I have good reason for doing so, any statement I may have made. But while doing this, it will be my most earnest wish to avoid the occurrence of anything which may seem captious or discourteous.

A great many of the objections raised by Professor Duncan against my several papers on the Madreporaria of our Secondary formations refer to mere matters of oversight, and as they do not affect the conclusions arrived at, are of little importance. They might prove useful on some future occasion in making corrections, were the papers to re-appear in a collective form. Objections of another kind take the form of direct and unsupported contradiction of facts, and there are again, some, which, from their very nature, and for the author's own sake, should be allowed to pass unnoticed. But such statements as affect the definition of genera and the determination of species, and have therefore a more legitimate bearing on the subject in hand, will receive due attention in their proper place.

A collection of specimens from the Inferior Oolite of Dorsetshire has lately been placed in my hands by Mr. Buckman, and these with others kindly supplied by Mr. Hudleston, with the addition of a collection made by me during a recent visit to the same district, have afforded me the long-wished-for opportunity of comparing the Dorsetshire and Somersetshire species with those from the counties of Oxford and Gloucester. A list of the Dorsetshire species will be given further on.

Diligent search has been made for Corals in the lowest beds of the Inferior Oolite at Crickley Hill, Leckhampton Hill, Cleeve Hill, and Frocester Hill, in consequence of the species already found in them having differed so materially from those in the more clearly defined coralliferous deposit overlying the Pisolite. They are, besides, interesting as being the earliest representatives of Madreporaria in the Oolitic formation, differing greatly in their facies from the few small corals which are found in the Upper Lias, though not nearly so much from those species which occur in the underlying Marlstone. The following are such as have up to this time been taken from the Pisolite, and the beds below it.

MONTLIVALTIA CONCINNA.—Pisolite at Crickley and Leckhampton, and in the broken-up bottom beds at Huddiknoll, near the Horsepools, Gloucester.

MONTLIVALTIA CUPULIFORMIS.—Beds under the Pisolite, Crickley.

MONTLIVALTIA DE LA BECHEI.—Bed under the equivalent of the Pisolite, Frocester Hill.

MONTLIVALTIA LENS.—Beds under the Pisolite at Leckhampton and Crickley, and in the beds overlying the Upper Lias sands, Dover's Hill, Chipping Campden.

ISASTRÆA, an undetermined species.—Bed under Pisolite, Crickley.

CHORISASTRÆA, sp.—Pisolite, Crickley, and the bed overlying the Upper Lias sands, Dover's Hill, Chipping Campden.

THAMNASTRÆA, sp.—Pisolite, Crickley.

THAMNASTRÆA, sp.—Bed overlying the Upper Lias Sands, Dover's Hill, Chipping Campden.

OROSERIS OOLITICA.—Bed under the Pisolite, Crickley.

COMOSERIS VERMICULARIS.—Pisolite ? Crickley.

Several of the above are either undeterminable or have already been passed under review, but mention will hereafter be made of some of them in the notes on the species.

Mr. Witchell, in his valuable work on the Geology of Stroud, records the occurrence of a Coral-bed resting on the Upper Trigonia Grit. The position being wholly at variance with that assigned to the Upper Coral-bed near Cheltenham by the late Dr. Wright, I have recently visited Stroud, and, under the guidance of Mr. Witchell, have examined one of the sections mentioned by him—the Stroud Hill section. The result has been the full confirmation of his opinion, that there are four coralliferous deposits in the Inferior Oolite of Gloucestershire, instead of three as stated by the late Dr. Wright. The Coral-bed exposed in Worden's quarry in the Slad Valley, Stroud, though supposed by Dr. Wright to correspond with the upper one near Cheltenham, is really of more recent date, and is indeed the same as the one in the Rodborough Hill and Stroud Hill sections. The position of these four coralliferous layers in the Inferior Oolite of Gloucestershire may be defined as follows :—

1. *The Upper Coral Bed.*—Occurs in the upper part of the Upper Trigonia Grit, and is exposed at Rodborough Hill, Stroud Hill, and in the Slad Valley, near Stroud.
2. *The Second Coral Bed.*—Lies in the bottom of the Lower Trigonia Grit, and is exposed at Cleeve Hill, Leckhampton Hill, Ravensgate Hill, Brown's Hill near Seven Springs, Juniper Hill near Painswick, and at Birdlip, all localities in the Cheltenham district.
3. *The Third Coral Bed.*—Lies in the Oolite Marl at Birdlip Hill, Leckhampton Hill, Juniper Hill, and at Notgrove on the Cheltenham and Chipping Norton Railway.
4. *The Fourth Coral Bed.*—Lies directly upon the Pisolite, and is well exposed at Crickley Hill, Birdlip Hill, Sheepscombe, the Horsepools, at Huddiknoll, and at Juniper Hill near Painswick. It is absent at Cleeve Hill and at the Leckhampton and Frocester Hills.

The Corals of Beds 2, 3 and 4 have already received attention, but those of Bed No. 1, have not been made known. It appears, however, to be very poor in species, only three having as yet been noted. They are, *Isastræa tenuistriata*, *Isastræa* sp. undetermined, and *Thamnastræa* sp. undetermined.

The following are the species from the Inferior Oolite of the counties of Dorset and Somerset which I have met with up to the present time, with their several localities, and, as far as determined, their Ammonite zones.

Discocyathus Eudesi. Burton Bradstock, probably in the zone of *Ammonites Parkinsoni*; Corton Denham, Somerset, in the zone of *Am. Murchisoni.*

Trochocyathus magnevillianus. Half-way house near Yeovil, in the zone of *Am. Parkinsoni;* under cliff, Burton Bradstock, probably in the same zone; in the "Marl Bed" at Bradford Abbas, in the bottom of the zone of *Am. Parkinsoni.*

Trochocyathus sp. A small conical species not yet determined, obtained by Mr. S. S. Buckman from the Bradford Abbas quarry, but the position not recorded.

Thecocyathus discus, E. de From. Burton Bradstock, the zone not noted, but associated with specimens of *Discocyathus Eudesi*, which were stated to have been taken from the zone of *Am. Parkinsoni.*

Thecocyathus, a species undetermined, obtained from the "Marl Bed" at Bradford Abbas by Mr. Buckman.

Montlivaltia lens. Bradford Abbas railway-cutting, in the zone of *Am. Murchisoni*, immediately overlying the sands; Castle Cary Hill in the zone of *Am. Parkinsoni*; Corton Denham, Somerset, in the zone of *Am. Murchisoni*; and in the zone of *Am. Sowerbyi*, at Bradford Abbas.

Montlivaltia de la Bechei. Bradford Abbas railway-cutting, in the zone of *Am. Murchisoni*; Drimpton near Broadwinsor, Dorset, in the zone of *Am. Parkinsoni*; Castle Cary Hill, Somerset, in the zone of *Am. Parkinsoni*; Bridport, the zone not noted.

Montlivaltia tenuilamellosa. A single specimen has been sent to me labelled Bradford Abbas, but it has more the appearance and colour of Burton Bradstock specimens.

Montlivaltia cupuliformis. Bradford Abbas, in the paving-bed at the top of the zone of *Am. Murchisoni*, where it is not uncommon.

Montlivaltia sp., undetermined, occurs with the last, and may perhaps prove to be identical with it.

Isastræa, sp. Not determinable. From the paving-bed at Bradford Abbas.

Latimæandra Flemingi? A species very nearly allied to, or identical with this, occurs in the paving-bed at Bradford Abbas, and is remarkable from having a thick and wrinkled epitheca.

——— ? A compound coral having calices in shape like those of an *Isastræa*, with confluent septa, and a columella, occurs at Bradford Abbas, but the zone has not been determined.

Thecoseris polymorpha. Several small specimens referable to this species have been taken from the paving-bed at Bradford Abbas, and I have one from the Inferior Oolite at Stoford, Somerset.

Leptophyllia, sp. (*Podoseris constricta*, Duncan). The type-specimen of *Podoseris constricta*, which was for some time in my hands, has so much the appearance of the Burton Bradstock specimens that I have no doubt that it was obtained from that place. It is stated to have come from the Lower Ragstone of Dorset, which I presume is the zone of *Am. Parkinsoni*, the zone from which the other Burton Bradstock Corals here mentioned have been obtained.

Thamnastræa Defranciana. A single example from the Inferior Oolite of Dorset is in my collection, but I do not know either its zone or exact locality.

Dimorpharæa Oolitica, Duncan, sp. Occurs at East Coker, and is common; also at Stoford near Yeovil, in the zone of *Am. Sowerbyi.*

Dimorpharæa Beanii (*Cyclolites Beanii*, Duncan). Occurs in the paving-bed of the Bradford Abbas quarry, in the upper part of the zone of *Am. Murchisoni.*

Dimorpharæa expansa, n.s. East Coker, the zone not ascertained.

Microsolena, a small globular species. Two examples have been met with, one from the paving-bed at Bradford Abbas, and the other, although said to have been collected at the same place, has so much the appearance and colour of the Burton Bradstock Corals as to leave little doubt that it came from there.

The number of *Turbinolidæ* in the above list, occurring so low down in the Inferior Oolite of Dorset and Somerset, is rather remarkable, and would seem to indicate a continuous period from the Upper Lias upwards, the conditions of which were favourable to the growth of these small Madreporaria, and which did not prevail during the formation of corresponding deposits in the Gloucestershire and Oxfordshire areas. The general resemblance between the *Turbinolidæ* of the Upper Lias and those of the Inferior Oolite of the Western Counties of England is very obvious.

The following section at present exposed in the quarry at Bradford Abbas was taken by me a few months since, and although it does not materially differ from those already given by Mr. S. S. Buckman[1] and Mr. Hudleston,[2] is repeated here for the purpose of showing all the more correctly the position of the Corals in it.

		ft.	in.
1.	Surface soil	0	6
2.	Shattered stone and rubble	3	6
3.	Stone in nodular layers, divided by thin irregular layers of marly shale	4	0
4.	Soft stone	0	8
5.	Marly shale; the "Marl bed" of S. S. Buckman. Contains *Trochocyathus magnevillianus*	0	2
6.	Gasteropoda bed, consisting of hard subcrystalline stone, which is thin and ragged and blue in the middle. It is overlain by a soft friable layer. It contains Gasteropoda of great beauty, and a considerable number of small sponges	0	9
7.	Yellowish compact limestone	2	0
8.	Paving-bed, containing the following corals:—*Montlivaltia cupuliformis*, *M. lens* and another species undetermined, *Latimæandra Flemingi*, a compound coral allied to *Isastræa*,		

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[1] Quart. Journ. Geol. Soc. vol. xxvi. p. 591.

[2] Proceed. Geol. Assoc. 1885, p. 198.

	ft.	in.
Thecoseris polymorpha, Dimorpharæa Beanii, and a species of *Microsolena*	0	8
9. Dewbed, forming the bottom of the quarry, and lying on the Midford Sands. Depth not ascertained, more than	1	0

I now proceed to notice such species of corals from the Inferior Oolite as appear to be either undescribed, new to this country, or as demanding further remark.

THECOCYATHUS DISCUS. From. et Fer., Paléont. Franc. Polyp. Terr. Jurass. p. 34, pl. 2, fig. 2.

I have received a specimen of this species said to have been obtained from Bradford Abbas, but which, from its colour and lithological condition, most likely comes from the same horizon and place as a number of specimens of *Discocyathus Eudesi*, that is to say, from Burton Bradstock.

EPISMILIA PORPITA, Tomes,

Montlivaltia porpita, Tomes, Quart. Journ. Geol. Soc. vol. xxxviii. p. 419, 1882.

The small Corals I described under the name of *Montlivaltia porpita*, as having very peculiar septa, have proved, when some of their septa were exposed by the removal of others, to have their sides ornamented by tubercles instead of vertical ridges. These tubercles are ranged in rows, which are parallel to the edge of the septa, and when the latter have been worn down, the upper row on either side comes close to the top, and the septa, which are in reality very thin, are rendered thick and rugged by them. Until fully exposed, they were mistaken for the upper ends of vertical ridges.

The genus *Epismilia* is one about which there has always been some doubt, attributable probably to the difficulty attending its determination from *Montlivaltia*. M. de Fromentel proposed it, and it was clearly recognized as distinct by M. Etallon, under the name of *Ellipsosmilia*, D'Orb. Thurman, Fromentel and Ferry, knew and made use of the differences between it and *Montlivaltia*, and so did Stoliczka, while Milaschewitsch not only adopted it, but pointed out a character by which it could more easily be recognized. He showed that the septa have small tubercules on their sides instead of ridges, and Prof. Koby, availing himself of that means of determination, has described ten species as occurring in the Jurassic deposits of Switzerland.

To the description I formerly gave of the present species, under the name of *Montlivaltia porpita*, I need only add the above. Though confident of the existence of the genus *Epismilia* in our Oolites, I could not determine the species when I wrote my former paper. One species may now, however, with certainty be introduced into our Coral fauna.

DONACOSMILIA WRIGHTI, Edw. and Haime sp.

This common species occurs in the lower or fourth Coral bed wherever it is exposed in the Cheltenham district, as well as in the third Coral bed at Leckhampton Hill. Crickley Hill has, however, supplied all the best specimens, and they show that it is a tall species, the corallites of which are placed close to each other. Many well-preserved calices have now been examined, and the generic characteristics fully made out. Prof. Duncan assumes that the simple corallum of *Axosmilia Wrighti* has been taken by me as the foot-stalk of *Donacosmilia*, but I never for a moment entertained such a supposition. On the contrary, I distinctly stated my belief that both *Axosmilia Wrighti* and *Montlivaltia Holli* were nothing more than single corallites of *Donacosmilia* broken off at their point of attachment to the parent stem, and I have seen nothing to induce me to modify that conclusion. The entire margins of the septa, which are so peculiarly characteristic and common to all the above-mentioned forms, are not so much as alluded to by Prof. Duncan in his late paper.

PLACOPHYLLIA GRACILIS, sp. nov. (Plate X. Figs. 5 and 6.)

Single corallites of a Coral having a gracile growth, and almost always in an indifferent state of preservation, have frequently been found in the Lower Coral-bed of the Cotteswolds. These could not be attributed to any known species, and were too fragmentary for description. Renewed search at those places where that Coral-bed is exposed has brought to light some better-preserved specimens, which may be described as follows:—

The corallum consists of a bush-shaped mass of rather closely placed and nearly parallel corallites, which have nearly the same diameter from the bottom to the top. Lateral gemmation takes places at considerable intervals, and the young corallites thus produced spring from the parent-stem horizontally, but speedily assume a perpendicular position by the side of the older corallite, and both grow upwards together. All the corallites, old and young, have a well-developed epitheca, which presents numerous and regular rings of growth. The walls are produced upwards, and with their epithecal covering, form thin and prominent margins to the calices.

The calices are ovoid and deep, and the fossula is elongated. The margins of the septa have very little curvature, but slope inward and downward in nearly a straight line. At the wall the septa are thick, but they diminish in thickness, and become quite thin as they approach the columella; though there is sometimes a little thinning just at their union with it. They are twenty-four in number, that is to say, three cycles in six systems. The first and second cycles are united to the columella, and two of the primary ones run into its two ends, and with it divide the calice longitudinally in half. The septa of the third cycle are three-fourths the length of the primary and secondary ones. There are a few rudimentary septa of the fourth cycle in some of the systems. The columella is thin, well defined, but not prominent, and is about one-third the entire length of the calice.

Diameter of the corallites from two to three lines. Their height cannot be ascertained.

This species bears considerable resemblance to the *Placophyllia rugosa* of Becker, from the Corallien of Nattheim.

STEPHANOCŒNIA DENDROIDEA, sp. nov. (Plate X. Fig. 10.)

I have long been familiar with fragments of a tall dendroid Coral from the Oolite Marl of Leckhampton Hill, which had characters I could not associate with any other Oolitic species, but which were too ill-preserved for identification. Some well-preserved pieces of a large specimen from Birdlip Hill, also from the Oolite Marl, having lately come into my hands, I am now able to describe this species as follows:—

The corallum is tall and branching, and attains to a height of a foot, or a foot and a half, and has very much the habit of growth of *Thamnastræa Lyelli.* The basal part has sometimes a diameter of as much as two inches, the horizontal section of which, as well as that of the branches, is nearly round, but they are nevertheless considerably nodulated.

The calices are evenly distributed, but are a little more distant from each other in the longitudinal direction of the branches. They are for the most part lozenge-shaped, ovoid, or even quadrangular; but the largest have a rounded outline, and there is a delicate but distinct line of depression between them. They are superficial, but have a circular and open centre.

The septa are short and stout, and they are continuous with those of adjoining calices, with which they unite, but yet are divided by the fine but distinct line before mentioned. When the septa are worn down, this line of depression is obliterated, and many of the united septa are very regularly geniculated. In a full-sized calice there are about thirty septa which are, generally speaking, of nearly the same thickness and length. Those, however, which have pali before them are a little stouter than the others. The pali are of nearly equal thickness and length with the septa, and in a calice having thirty septa there are fourteen pali, that is to say, nearly each alternate septum has one before it.

The columella is small and deeply seated. It is styliform, though a little compressed, and it is united in some of the calices to one of the pali. Both septa and pali are regularly denticulated, and the greater diameter of the denticulations is across the septum. This is most distinctly observable towards the ends of the branches, where the calices are circular and much more prominent.

When the septa are worn smooth and the lines of junction with those of contiguous calices are obliterated, this Coral has much the aspect of a *Thamnastræa.* Gemmation appears to take place in the interval between the calices, where smaller calices are observable. There is so much similarity between the septa of this species that I am wholly unable to trace the cycles. The cycles of the pali for the same reason are equally difficult of determination. The appearance presented is that of a calice with fourteen principal septa, and their pali. The diameter of the calices is about one line.

Although the genus *Stephanocœnia* is placed in the *Eusmelinæ*, and for want of better information respecting the Oolitic species I have placed the present species in that family, I am by no means assured that it should not be included in the *Astræinæ.* That both septa and pali are distinctly denticulated is obvious, and that, with the union of the columella with one of the pali, should that prove constant, indicates a distinct genus.

Of the walls or endotheca I possess no information, the whole of the inside being crystalline.

STEPHANOCŒNIA EXPANSA, sp. nov. (Plate X. Fig. 11.)

The corallum consists of a thin and somewhat rounded plate, the edges of which are very thin, turned up, and a little undulating, and there is on a part of it a second or superimposed plate which partly covers the original one. The under surface has the middle part most prominent, by which it appears to have been broadly attached. There is an epitheca with faint concentric wrinkles. The whole of the upper surface is furnished with calices which are much smaller and shallower than those of *Stephanocœnia dendroidea*. As in that species, they are lozenge-shaped, ovoid, or round, and the depression bounding them is small but distinct, but the septa are continuous with those of adjoining calices. There are from thirty to thirty-seven septa, of which twelve are a little more developed than the others, and have pali before them. Twelve others have the same length, but are a little less stout, and the remainder are about two-thirds of that length, and are much thinner. Both they and the pali are a little exsert, and have their margins denticulated. The fossula is small, but well-defined, and contains a slightly depressed but styliform columella, which is larger relatively than in the preceding species.

The endotheca has not been observed.

Gemmation takes place in the interval between the calices.

Only one specimen has yet been met with. It was taken from a coralliferous stratum at Cooper's Hill, near Gloucester, which holds precisely the same stratigraphical position as the one at Crickley Hill.

Diameter of the corallum, three inches; its height about three-quarters of an inch; diameter of the calices, a little less than a line.

MONTLIVALTIA PAINSWICKI, Duncan.

Many specimens of this species have now been taken from the Lower Coral bed at Crickley, Birdlip, the Horsepools, and in the Painswick valley, most of which are small in size, the largest not exceeding that of the type-specimen figured by Professor Duncan. As a species it may be distinguished by the tendency to have one or more of its sides flattened. The form of the calice varies a good deal. When one side only is flattened, it has a rudely-formed semicircular outline. It may be more or less triangular or quadrangular, or indeed polygonal, according to the number of flattened sides of the corallum. There is an indication only of flattening of one side in the specimen figured by Professor Duncan, which was for some time in my hands. The calice of that specimen is deeper than is usual, owing to the septa having been somewhat worn down.

In the Oolite marl this species attains to a greater size than it does in the Lower Coral-bed. Two examples from that horizon at Birdlip

Hill are attached, the one to a corallite of *Donacosmilia*, and the other to a shell. They are three times the size of the figured specimen.

Several specimens of this species obtained from the Inferior Oolite in the railway-cutting at Hook Norton, Oxfordshire, have been sent to me with other Oolite corals by Mr. Hudleston. In all of these the flattened side, though visible, is only a little indicated.

Milaschewitsch pointed out that *Oppelismilia gemmans*, Duncan, was nothing more than a *Montlivaltia* which had been subjected to that sort of interrupted growth to which he gave the name of rejuvenescence. This growth, Professor Duncan maintains, is only what was long ago called by MM. Milne Edwards and Haime, "bourrelets d'accroissement," or growth-rings. It is, however, at the present moment, quite unimportant under what name we speak of it, but it is very important that we should distinguish very clearly between it and calicular budding, which is wholly different. But after the recent remarks by Professor Duncan on the subject, I can only conclude that he still confounds the two processes. He now places in the subgenus *Oppelismilia* the so-called *Montlivaltia Holli*, the "*Montlivaltia turbata*, Milasch., and any forms which Mr. Tomes may have noticed with calicular budding." If the so-called *Oppelismilia gemmans* has calicular budding, then have we a very extensive list of species of *Oppelismilia*, and the much crowded and difficult genus *Montlivaltia* will be materially and unexpectedly relieved. A very large per-centage of Lower Lias Montlivaltiæ will have to be withdrawn from that genus, and amongst others *Montlivaltia rugosa*, *M. mucronata* and *M. Haimei*, while from the Oolitic Montlivaltiæ a goodly number must also be eliminated.

In like manner a considerable number of genera or subgenera will have to be created for such compound corals as have the same sort of growth as in the so-called *Oppelismilia*. For instance, I have now before me a specimen of *Cladophyllia Babeana*, some of the corallites of which exhibit gemmation, supposing it to be gemmation which takes place in the supposed *Montlivaltia Holli*, and if one species of the genus *Cladophyllia* is really subject to calicular budding, it must, by a similarity of argument to that applied by Prof. Duncan to *Montlivaltia*, be separated from the other species of *Cladophyllia*. But it is an error to suppose that calicular budding takes place in either case, and even had it been so, it would still have been inconsistent in the extreme to retain *Montlivaltia Holli* (which is distinctly affirmed to have calicular budding) in the genus *Montlivaltia*, while for another *Montlivaltia* a new genus (*Oppelismilia*) was formed, for no other reason than that it had calicular budding.

MONTLIVALTIA CONCINNA, Tomes.

Subsequently to the description of this species several specimens were obtained, and with the exception of a single example they were taken from the Pisolite. They confirm the specific characters already given. This species may now be regarded as being invariably attached by a somewhat expanded foot, and as having an undulating calicular margin, which is sometimes partially everted as in the specimen originally described. The thickness of the septa near to and at the wall is observable in all the specimens I have seen, and is a distinctive character.[1] It occurs in the Pisolite at Crickley Hill, Leckhampton Hill, and at Huddiknoll near the Horsepools, and a single example has been taken from a sandy bed immediately above the Upper Lias sands at Dover's Hill near Chipping Campden.

MONTLIVALTIA DE LA BECHEI, MM. Milne Edw. and Haime.

I have collected specimens of this species from the well-known section of the Inferior Oolite at Frocester Hill, where it is confined to the upper layer of the compact stone marked C in Dr. Wright's section,[2] which immediately underlies the equivalent of the Pisolite. The stratigraphical position corresponds therefore with that of the allied species *Montlivaltia lens* at Crickley and Leckhampton Hills. It is by no means rare at Frocester, but is with difficulty extracted from the stone. I have also taken this species from an exposure of a few feet of Inferior Oolite in the road leading from Bath to Combe Down, at a place called Holloway, and by the kindness of Mr. George I have had the use of a number of small examples which had been collected at Dundry. By the list of Dorsetshire species it will be seen that it occurs in several places in that county.

MONTLIVALTIA CUPULIFORMIS.

A single example of this species was all I had seen in 1882, and no other one has been met with from the same locality. I have, however, been favoured by Mr. S. S. Buckman with several examples from the Inferior Oolite of Bradford Abbas. In the original specimen obtained by me from Crickley, the adherent base is as broad as is represented in the figure given by the original describers, but in those from Bradford Abbas the constriction near the foot is, generally speaking, much greater, and the upper part of the corallum much more globose. None of the specimens from Mr. Buckman are attached, the narrow foot having been fractured.

MONTLIVALTIA sp.

There is a very distinct layer about the middle of the Pisolite at Cleeve Hill, Cheltenham, containing large flat concretions. Some of these are much overgrown with Bryozoa and small sponges, and occasionally a very young and attached *Montlivaltia* may be observed. The species is not determinable, none of the examples yet examined having attained to any visible height, while the greater number of them have not even reached that period of growth when the inclosing wall first shows itself.

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[1] I think it right to suggest the possibility of this and some other Montlivaltiæ having wavy and everted margins, being merely the peduncles of a compound genus. The abnormal septa of the present species, as well as the excessively numerous ones of the species from the Middle Lias of Charmouth which I have described under the name of *Montlivaltia foliacea*, may prove to be costal prolongations of the septa in progress of development preparatory to gemmation.

[2] Quart. Journ. Geol. Soc. vol. xvii. p. 9, 1860.

CYATHOPHYLLIA OOLITICA, Tomes.

Repeated and diligent search for this species has been rewarded by the acquisition of two additional specimens, one from the Crickley Coral-bed, and the other from the same horizon at Huddiknoll, near the Horsepools, Gloucester, where the bed is much broken up and in a mixed condition. In neither of these is the columella so large or so clearly made out as in the type-specimen.

Prof. Duncan takes great exception to my retaining the genus *Cyathophyllia*, and after quoting Reuss and Pourtales, and giving cogent reasons for merging it into *Antillia*, as a subgenus of *Circophyllia*, observes that the facies of the Oolitic species of *Cyathophyllia* is not that of *Antillia*, and further "that any one who had studied the simple *Fungida* would place the form in the neighbourhood of *Thecoseris*, E. de From., the uniting and numerous septa being strong characters amongst the group. One must demur, therefore, to the admission of this comparatively unexamined form into the genus *Antillia* (which has precedence of *Cyathophyllia*)." Certainly. And I do most decidedly demur to its being placed in *Antillia*, even with the approbation of Reuss and Pourtales, and fully intend to retain it in *Cyathophyllia*. Examples of *Cyathophyllia liassica* (the type species) and *Cyathophyllia Oolitica* are now before me, and in both I observe the same crowded and anastomozing septa. Their generic identity does not admit of any doubt, nor does any doubt exist in my mind as to the propriety of retaining *Cyathophyllia* as a genus.

THAMNOSMILIA, gen. nov.

In the Oolite Marl of Leckhampton Hill, and at no other place, so far as I at present know, is a branching coral which possesses some of the characters of *Rhabdophyllia*, with the addition of a well-developed and rugose epitheca. Although by no means rare there, all the specimens I have seen have been completely inclosed in matrix, and could only be obtained by the use of the chisel and graver on some of the softer blocks. I define the genus as follows:—

The corallum is bush-shaped, the corallites lessening in size very gradually. Branching occurs unfrequently, and the branches are thrown out at a considerable angle. The wall is thick, and the epitheca well developed and very rugose. The calices are deep, circular, and their margins are thin. The septa are numerous, anastomozing, and passing into the columella, which is large, rugged, and spongy.

THAMNOSMILIA ANNULATA, sp. nov. (Plate X. Figs. 7, 8, 9.)

The corallum is not of great size, the greatest diameter of a corallite being only half an inch, and it consists of a peduncular portion attached to a shell. Generally the corallites have a diameter of two or three lines. They are seldom straight, but very frequently considerably curved. The epitheca is very thick and wrinkled, and disposed in rings around the corallites; they are nearly equidistant from each other and of nearly equal size, and they are continued the whole height of the corallites. The calices are very deep, almost circular, and a little expanded just at the margin, which is thin. The septa of the small corallites are not numerous, being about 21 or 24 in number, that is to say, there are three cycles. Of these the septa of numbers one and two pass up to the columella, and those of cycle number three often bend towards and become attached to the earlier ones. In the larger corallites there are a great many more septa, and the cycles cannot be traced owing to their anastomozing so much. In the calicular surface of the peduncle I have mentioned there are at least fifty septa, and the older ones unite with each other, mostly in pairs, quite close to the columella, into which when united they often pass, while the newer ones run into the older ones at points more or less remote from the columella, according to their age. I have not as yet met with a perfect calice, that is to say, one in which the septa have their margins uninjured, and I cannot therefore describe them with any degree of completeness, but so far as I can observe, there is no ornamentation of any kind on their sides.

The columella is rather large, rugged, and spongy; its upper surface having about ten or twelve papillæ. It is deeply seated in the calice, and has no convexity.

The height of the corallum has not been ascertained.

Genus ——— ?

I have met with some portions of a dendroid Coral at Crickley and at Cooper's Hill, near Cheltenham, which I have failed to place satisfactorily. Its ramifications closely resemble those of *Donacosmilia Wrighti*, and increase takes place by lateral gemmation near the calice, just as in that genus, and there is usually a constriction at the attachment of the new corallite to the old one. As in *Donacosmilia* there is a well-developed epitheca. But it differs essentially from that genus in having numerous and very thin septa which have their sides ornamented by rather numerous and well-defined vertical ridges, ending in prominent points on their upper margins. The earlier formed cycles meet in the centre of the visceral cavity, and there form a rugged columella, which has its upper surface toothed like the margins of the septa. Where the epitheca has been worn off, numerous dissepiments are exposed.

I am at present unable to refer this species to any known genus, and the specimens are too fragmentary to admit of the formation of a new one.

EXPLANATION OF PLATE X.

Fig. 1. *Platastræa endothecata*, sp. nov., the under surface of the corallum of a small specimen (natural size).
,, 2. ,, ,, a portion of a larger specimen (natural size) showing the form of the calices and the continuity of the septa.
,, 3. ,, ,, the upper margin of a septum, magnified four times to show the denticulations.
,, 4. ,, ,, a portion of the lateral surface of a septum, magnified five times to show the regular and arched dissepiments.
,, 5. *Placophyllia gracilis*, sp. nov., the corallum, natural size.
,, 6. ,, ,, a calice magnified four times.

Fig. 7. *Thamnosmilia annulata*, sp. nov., a portion of a corallum, natural size, showing the rugose epitheca.

" 8. " " calice of the same specimen (natural size).

" 9. " " some septa magnified 2½ times, showing their connection with the columella. In this and in the foregoing figure, the septa are dark in colour as in the original; the infilling of the loculi being white.

" 10. *Stephanocœnia dendroidea*, sp. nov., three calices, magnified six times.

" 11. " *expansa*, sp. nov., a calice, magnified nearly 14 times.

In neither of the figures of *Stephanocœnia* are the denticulations of the septa shown.

(*To be continued in our next Number.*)

II.—Note on the Recent Volcanic Eruption in New Zealand.

Communicated by Robert Etheridge, Jun., Esq.,
of the British Museum.

THE "Lake District" of the North Island is too well known to all students of volcanic phenomena, especially of that branch comprising hydrothermal action, to need a detailed description. It will be sufficient to say that it forms a belt, crossing the island from north-east to south-west, and forms a portion of the Middle and Upper Waikato Basins of Hochstetter. The district has been recently brought into prominent notice by the disastrous eruption of Mount Tarawera, very full accounts of which have appeared in New Zealand papers lately received. The eruption commenced in the early morning of Thursday, June 10th, but premonitory symptoms showed themselves a few days before in a tidal wave, three feet high, on Lake Tarawera, great uneasiness of the springs at Ohinemutu, and the reported appearance of smoke issuing from Ruapehu, the highest of the great trachytic cones at the extreme south-westerly end of the system. The belt of activity extends from Mount Tongariro at the one end to White Island, in the Bay of Plenty, at the other, a distance of about 150 miles. White Island has undergone considerable change from volcanic action during recent years, and Tongariro was last in eruption in July, 1871; whilst its snow-clad sister cone Ruapehu has never manifested volcanic action within the historic period until now. This wide zone in the centre of the North Island has, ever since the arrival of the Maoris, been the scene of such extraordinary phenomena, that it has of late been the resort of visitors from all quarters of the globe.

At 2·10 A.M. on June 10th the inhabitants of the rising town of Rotorua were aroused by a violent earthquake, accompanied by a fearful roar, whilst away to the south Mount Tarawera appeared to be in eruption, an immense black mushroom-shaped cloud hanging over the whole country from Taheke to Pairoa Mountain, accompanied by lightning and heavy peals of thunder. About 4 A.M. ash-dust began to fall, but a shift of wind turned it coastwards, "where it worked its calamitous will to the full." As the day wore on it was found that Rotorua had not suffered much beyond this covering of dust and the appearance of fresh boiling springs, neither had the celebrated hot bath of Ohinemutu suffered. On the opposite side of Lake Rotorua, however, the mud-hole of Tikitere, noted for its violent spouting and smell, had broken out.

It appears from later accounts that this volcanic outbreak commenced at Ruawhia, one of the three peaks into which the cone-like Tarawera is split. This volcano stands on the southern shore of the lake of the same name, and is about 2000 feet high; but no tradition of its ever having been active before exists amongst the Maoris. Indeed, it had been used by them for centuries as a place of sepulchre, somewhat after the manner of the Parsees and their "Towers of Silence." At the early stage of the eruption it was found that three large craters had developed themselves on Mount Tarawera, whilst a fourth was afterwards ascertained to have opened on the flank towards Lake Rotomahana. From these were belched forth flames and large quantities of stones, ash-dust, and clouds of smoke, which passed over the country both in a northerly, north-easterly, and southerly direction.

It was, however, at the Township of Wairoa on Lake Tarawera, midway between Rotorua and Mount Tarawera, that the greatest devastation took place and injury to life and property. Violent earth tremors were experienced between 1 and 2 A.M., accompanied by showers of ash-dust, and followed by that of stones and volcanic mud, which ultimately buried the whole place to the depth of ten feet. The houses were demolished, both those of Europeans and Maoris, and many persons killed, including Mr. C. A. Hazzard, the resident schoolmaster, and members of his family. Had it not been for the great intrepidity of Mr. McRae, proprietor of the Rotomahana Hotel, which was also destroyed, a further loss of life would have doubtless taken place. The pretty Tikitapu bush between Wairoa and Rotorua was completely destroyed, and the ground covered to a depth of three feet with dust; trees of 170 feet in height uprooted, and forming in places tangled masses ten feet thick. All undergrowth was swept away by the accompanying storm, and vegetation destroyed. The waters of the Tikitapu and Rotokakahi Lakes, celebrated for their blue and green colours, were changed to a dirty brown tint, and the outlet of the latter to the larger lake Tarawera was blocked, and its course altered.

The explosions which took place during the eruption of Mount Tarawera were plainly heard in Auckland, 180 miles to the north, and also at Te Aroha. Earthquakes were experienced at Tauranga, Maketu, and Opotiki, on the shores of the Bay of Plenty, and dust showers took place at each. At Cambridge and Hamilton, north-west of the more acutely disturbed district, and between it and Auckland, reports of heavy explosions were heard, and the windows shaken; and much the same phenomena were observed at Coromandel. Even at such distant places as Dunedin and Christchurch, in the South Island, electrical disturbances were manifested, believed to be traceable to this volcanic outbreak.

On June 13th matters had calmed sufficiently to allow exploration and relief parties to proceed beyond Wairoa, and ascertain the condition of the world-reputed Lake Rotomahana, and the fate of the Maori settlements on the southern arm of Lake Tarawera. The expeditions in question were conducted by Mr. James Stewart, Major Mair, Mr. G. M. Reed, Mr. McRae, the Warbrick Brothers, and Mr. H. Steele, with Dr. Hector, the Government Geologist, at great personal risk and after much acute suffering. The sum of their reports was, that Lake Okaro and Mount Kakarema, to the south of Rotomahana, were in their normal condition, but along the creek connecting the former with Lake Rotomahana four craters had broken out, as well as a large one, 400 yards long, on the flank of Mount Tarawera, overlooking Rotomahana, where all had before been fern and tussock grass, throwing up showers of stones, dust, and volcanic mud. Rotomahana itself appeared to be one immense cauldron, composed of a series of smaller craters in full action, of which eleven to fifteen were counted, belching out clouds of steam, stones and mud. The site of the Pink Terrace was occupied by one of the largest of these, but that of the White Terrace was "clean blown out of existence," and occupied by immense fumaroles. The dividing line between the mud eruption and the showers of dry dust over the surrounding country was remarkably well shown. From Rotomahana towards the south-west, the latter extended around Lake Okaro, and back to Lake Rerewhakaitu, covering an area of not less than seven square miles. Away to the northward, the whole of the north shore of Lake Rotorua "wore the grey drab tint of the volcanic *debris*." It now appears tolerably well proved that it was the mud from the volcanoes developed on the site of Lake Rotomahana that destroyed the ill-fated Wairoa township; as well as the Maori settlements of Te Ariki and Moura on Lake Tarawera, with all their inhabitants. This volcanic mud has covered a very large area, from fifteen to twenty miles in length, by an average breadth of ten or twelve miles. It extended from Rotomahana on the south to near Ohinemutu on the north, and along the shores of Lake Rotorua to Ta Heke. The depth varied from a few inches to ten feet, but at Te Ariki, near the point of ejection, it was estimated to be at least thirty feet in depth, and it was very heavy, which will account for the manner in which the houses at Wairoa were crushed down.

Dr. Hector, C.M.G., F.R.S., is stated to have expressed the opinion that the earthquake shocks caused by the outbreak of Mount Tarawera ruptured the steam pipes in the Rotomahana geysers, and let in the water of the lake upon the subterranean heat, resulting in the generation of enormous quantities of steam, and the ejectment of the mud at the bottom of the lake. The material thrown out by Mount Tarawera appears to have been more of the nature of a white earthy pumiceous dust, but so far as yet known lava has not been observed. The pumiceous dust was examined by Profs. Brown and Thomas, of Auckland University College, who report on a sample obtained at Tauranga, that it consisted of angular grains of quartz, volcanic glass and finely divided pumice, fragments of felspar, hornblende, and other volcanic minerals.

My colleague, Mr. Thomas Davies, F.G.S., of the Mineralogical Department, British Museum, has examined samples of the dust sent home by Mr. Henry Gray, of Auckland, and collected at Rotorua, and also at Tauranga, which is from forty to fifty miles from the points of eruption, and finds, the former, which is the coarser, consists of pumice, a glassy scoria, subangular quartz-grains, and a felspar which is probably orthoclase; the latter is of the same materials, but finer, and includes more pumiceous dust.

We cannot do better than close this brief account of the Tarawera eruption by quoting the statement of two of the explorers, Mr. H. Steel, and Mr. Blomfield, artist to the *New Zealand Herald*, who appear to have approached nearer to the points of eruption than any other explorers, up to the time our last advices left New Zealand.

"We reached a very high and steep hill, almost perpendicular, immediately above what once was Rotomahana Lake, but which is now an immense basin, studded with hundreds of small volcanic cones, geysers, fumaroles, and ngawhas, a regular witches' cauldron, awful and terrible . . . . . From the point at which our party was standing we enjoyed a good view of Tarawera Mountain, Rotomahana, and the line of volcanoes between Rotomahana and Okaro Lake. One of these was throwing up black mud to a great height. It was forming a high bank of mud on the western side of its crater. An immense body of steam was rolling out of a large circular hole, some two or three chains in diameter. Other volcanoes were throwing out what seemed like a mixture of steam and smoke, but no lava was proceeding from any of them. Low down on the Tarawera Mountain, across the lake, a crater was still smoking, and from its lower lip there was a large fissure, through which Rotomahana Lake had evidently burst into the volcano. By this means an immense amount of steam had doubtless been generated, and the explosion which blew the bottom and sides out of the lake, leaving it an almost dry basin, had followed. We observed several other craters on the Tarawera Mountain still smoking, and in the one opposite to us we noticed a large deposit of pure sulphur. . . . . . The view obtainable from the top of the upper hill, the nearest point to which any one had penetrated, was always more or less obscured by the steam rising from the basin.

"From the top of the hill above mentioned the ground sloped almost perpendicularly, and Mr. Blomfield and myself went down the first half of the hill in grand style, without realizing the difference between going down and climbing back again. However, we had this brought forcibly to our minds very soon afterwards. We landed on a small terrace, and then the descent of another hill (not so steep) landed us on a small mud flat which lay between the foot of the hill we had come down and the edge of the crater—that is, of the place where Lake Rotomahana once was. We walked to within five feet of the edge of the abyss, and looked over, and saw a sight which I do not think either of us will ever forget. The wind blowing from the north lifted the steam and disclosed the dry bed of Rotomahana, which is now one scene of volcanic action, impossible for words to describe. . . . . A few pools of dirty boiling water still existed at the western end, and a rather large one at the eastern end. Hundreds of volcanic cones were throwing out steam, and what appeared to be black smoke. Scores of geysers were playing away merrily, throwing water many feet into the air. In one place a small plateau of mud had been thrown up, and on it was a pool of yellow boiling water, from one end of which a jet of dirty smoke or steam as thick as a man's body was issuing. About one hundred yards from the western end a large volcano, in very violent action, kept up a continual discharge of mud and steam, accompanied by a heavy rumbling, roaring sound. It would be impossible to describe the wonders of the scene in their infinite variety of volcanic grandeur. We were then standing on the bank above where the Pink Terraces formerly existed. The whole southern bank of the lake has been blown completely away, and the spot where the Terraces once stood is now an open gap. We next walked round the crater to the western end of the lake, to try to obtain a view of the White Terraces. Having waited till the steam lifted, we then saw that the White Terraces were also gone. The appearance of the place where they had stood was entirely changed, but a very active geyser was still playing. Returning back to where we first came down to the crater's edge, Mr. Blomfield took a sketch of the scene before us. We then started on the return climb—a very different thing from the descent. After a long pull, we got on to the first terrace, and then began the ascent of the big hill. We slowly crawled up its steep face, digging our hands and knees into the soft mud of which it was composed. . . . . We stopped to rest every few minutes, preventing ourselves from slipping back by thrusting our arms straight into the face of the hill, but when we got within thirty feet of the top, a slight earthquake shock, which shook the hill and sent the sand down round us, acted like a refresher, and we made good time to the top, where we found the rest of the party."

It is also reported that Tarawera had developed seven craters on the Tarawera Peak proper, and three on Ruawahie. It is further believed that those on the immediate site of Rotomahana will remain permanent.

III.—THE UNCONFORMITY BETWEEN THE BAGSHOT BEDS AND THE LONDON CLAY.

By the Rev. A. IRVING, B.Sc., B.A., F.G.S., of Wellington College.

IN the paper on the well-section at Brookwood in the August Number of the GEOLOGICAL MAGAZINE,[1] the author pointed out that a comparison of the lithological facts brought to light in that section with those furnished by two other deep-well sections (at Wokingham and Aldershot respectively) lead to an inference in favour of a considerable amount of denudation of the London Clay having taken place during the deposition of the Bagshot Beds; that is to say, irrespectively of the particular horizon in the Bagshot Series to which certain marginal portions of the Bagshot Beds may be ultimately assigned, there seemed to be pretty clear evidence furnished, from the London Clay itself, of the fact, that along their northern and southern flanks the *Bagshot Beds rest on beds belonging to lower horizons in the London Clay formation* than those on which the Bagshot Beds rest in the more central portions of the area. The present brief paper is an attempt to show that the above conclusion is borne out by a much wider induction from data gathered from the area of the London Basin in general. I have carefully gone through the 448 well-sections appended to Mr. Whitaker's Memoir on the London Basin,[1] and have selected from among them such instances as seemed to throw any light upon this question. A large majority of those sections include the London Clay; but since, in a great number of them, the thickness of that formation in feet is given only, unaccompanied by any lithological notes on the strata, they have been omitted, as affording no help to us in the present investigation. There are, however, as many as 29 sections, in which such notes appear. In every one of these the Reading Beds or the Thanet Sands, and in most cases both these formations, were proved below the London Clay, so that we are quite sure of a *correct basal horizon.* In many instances also the Basement Bed of the London Clay is noted. In 22 of these 29 sections, the thickness of the London Clay is less than 200 feet, and in all these there is mention of such inclusions in the strata as 'green sand,' septaria ('clay-stones'), pyrites, flint pebbles, and 'shells.' These therefore agree in this respect (without a single exception) with the lower half or rather more of the London Clay of the Brookwood section, as shown in the deep well at the Asylum on Knap Hill, which also (as shown in my last paper) agrees with the London Clay strata pierced at Wokingham on the northern, and at Aldershot on the southern, margin of the Bagshot area. From this I conclude that in all these 22 sections we have (within their several limits) homotaxial equivalents of strata of the lower half or rather more of the London Clay, as that formation is proved in the Brookwood section.

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[1] While that paper was passing through the press, the author was informed by the contractor, Mr. S. P. Coaker, that "a very perfect shark's tooth was found at the depth of about sixty feet." May not this have been derived from the London Clay?

In the remaining seven sections there is no mention of septaria, etc., above about 200 feet from the base of the London Clay. Of course this does not absolutely prove the absence of them, in these seven sections, but the number of instances is sufficiently large to establish a high degree of probability that they were not found at those higher horizons; and in every case there is mention of them at horizons below. The list from which this inference is drawn includes sections at Aldershot Place, on the south side of the area, at Hampstead, Harrow, Braintree and Chelmsford, on the north, and at Canterbury in the extreme east. The great majority however are in the metropolitan portion of the area. One of these (at Wimbledon) corresponds so well with the Brookwood section,[2] that it deserves to be given here more in detail, as follows:—

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[1] Memoirs of the Geol. Survey of Great Britain, vol. iv.

[2] Geol. Mag. August, 1886.

		feet.	
	Soil and clay (brown)	3	3
London Clay.	Lead-coloured, hard, flaky clay	20	
	Reddish sand and lead-coloured clay	80	
	Lead-coloured, strong loam	60	
	Lead-coloured clay or loam, with stony nodules (septaria)	40	
	Hard rock	½	
	Lead-coloured clay with much sulphur, many lumps of stone, giving off "noxious air," some rotten wood below	236	
	Hard rock	½	
	Total thickness of London Clay		437
			440 ft.

This well was "sunk all the way."

At page 282 of the Memoir, Mr. Whitaker mentions a section in the Wimbledon neighbourhood, which shows a passage upwards from the London Clay into Bagshot Sands. This bears out the inference which I drew in my last paper from lithological evidence very similar to that cited by him, as to such a passage occurring in the well-section at Brookwood.

It is of course a rare thing in wells in these Tertiary strata to come across a shoal of fossils, such as that mentioned by me[1] elsewhere, as occurring in the green earthy sand of the Middle Bagshots at Yateley, Hants; but isolated fossils are occasionally met with, and generally, as might be expected, in a good state of preservation in the London Clay. In the deep well at the Ascot Racecourse, of which I have already published an account,[2] the following, which are now in my possession, were found: *Pholodomya margaritacea* (192 above the base); *Cyprina planata* (a rather young individual). A well-rounded pebble of flint was also found at 75 feet above the base of the London Clay.

Prof. T. Rupert Jones, F.R.S.,[3] has also mentioned the following as met with in the Wokingham deep well: *Cardium, Cyprina planata, Pholodomya virgulosa, Nautilus, Panopæa intermedia, Pinna* (fragment), *Dentalium, Actæon, Natica, Astarte, Cytherea tenuissima, Ditrupa.* These forms range through the whole of the 273 feet of the London Clay pierced in that section, including the Basement Bed.

From Mr. Phillips's brick-yard, close by Wokingham Station, and a few feet only below the unconformable junction of the Bagshot Sands and the London Clay, which is seen just below St. Paul's Church,[4] I have obtained the following forms: *Cypræa Bowerbankii, Cardium Laytoni, Corbula Regulbiensis* (?), *Modiola elegans, Panopæa* (fragment), *Pleurotoma gentilis, Vermicularia Bognoriensis.* Some of the septaria found in this pit are charnel-houses of scarcely any other forms than *V. Bognoriensis.* The presence of these forms would seem again to indicate a tolerably low horizon in the London Clay for the beds on which the Bagshot Sands at Wokingham are superimposed. Oxidation-products of pyrites and flint pebbles are common in the London Clay here.

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[1] Q.J.G.S. August, 1885, p. 500.

[2] Proc. Geol. Assoc. vol. ix. No. 5.

[3] Geol. Mag. Decade II. Vol. VII. pp. 422, 423.

[4] Q.J.G.S. *loc. cit.* p. 505, fig. 4.

From the London Clay at Aldershot, in the brick-yard due south of the Station, I have obtained *Cypræa Bowerbankii*, *Modiola elegans*. The last-mentioned is very abundant in the septaria of that locality.

In his excellent work, *Stratigraphical Geology and Palæontology*,[1] Mr. Etheridge remarks: "Prof. Prestwich has shown that there are traces of palæontological zones in the London Clay, the lowest indicating in the east of the area of deposit a maximum depth of water (500 feet), while a progressive shallowing is seen in the higher zones, the uppermost of which contains the chief part of a terrestrial flora, as well as the fish and reptilian remains, all of which are seen in the Sheppey Beds."

The thicknesses given by Prof. Prestwich[2] for the London Clay, as proved in two wells at Sheerness, are 347 feet and 356 feet, very near approximations to the least thickness (371 feet) assigned in my last paper to the same formation in the Brookwood section. There too, according to Mr. Whitaker,[3] "the London Clay has a more loamy character and brown colour; there are also some beds of sand (north of Wyburns) which become more numerous further east, so that *there is no sharp line of demarcation between the undoubted London Clay and the overlying sand, which has been referred to the Bagshot Series*." This corresponds very well with what I have described as indicating a passage in the Brookwood section; while such features are conspicuous by their absence in all sections where I have seen the Bagshots resting on the London Clay along the flanks of the present Bagshot area.

It is much to be regretted that the works at Brookwood were not watched during the progress of the well through the London Clay. As it is, there would appear to be no record of any traces of a 'terrestrial flora' or of 'fish and reptilian remains' to correspond with those of the Sheppey Beds. In the most complete as to its details of the well-sections referred to in this paper — that of the Wokingham Town Well—furnished on so excellent an authority as that of Prof. T. Rupert Jones, there is no mention whatever of any traces of those remains which seem to characterize the higher zones of the London Clay; nor have I met with any in the brickyards at the surface. It would appear, therefore, that at Wokingham the evidence furnished by the London Clay itself, as to the removal by denudation of all the upper portions of that formation, before the Bagshot Sands were deposited upon it, is pretty direct and conclusive; and this entirely harmonizes with the observations, which I have previously recorded,[4] of the evidence of erosion of the London Clay beneath the Bagshot Sands at Wokingham, and the occurrence of rounded flint pebbles on that eroded surface at the bottom of the Bagshot Sands there exposed.

Taking all the facts adduced in this paper, and comparing them with those mentioned in my paper on the Brookwood section, it is difficult to see how we can arrive at any other conclusion than one favourable to unconformity, *from evidence furnished by the London Clay itself.*

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[1] Page 610.

[2] Q. J. G. S. vol. x. p. 404, quoted by Mr. Whitaker at p. 469 of the Memoir on the London Basin.

[3] Memoir, p. 317.

[4] Q. J. G. S. August, 1885, pp. 504, 505; Proc. Geol. Association, vol. ix. p. 222.

Where this formation exists in its full normal development, with Bagshot Beds superimposed upon it, there appear to be clear signs of a passage from one formation into the other: on the other hand, where—as in sections elsewhere described by me—on the marginal portions of the Bagshot area, the transition is an abrupt one, the stratigraphical data furnished by the London Clay seem to lead to the necessary inference, that the upper beds of that formation, to the extent of probably 100 to 150 feet in thickness, were removed by denuding agencies (furnishing perhaps the clayey materials of the Middle Bagshots[1]) before the Bagshot Beds were deposited upon the London Clay in those localities.

Note.—In generalizing from a number of deep well-sections in a given geological district, it would be mere pedantry to insist upon the exact value of the measurements in every case. Errors may arise from tubes getting out of the vertical, and from the materials getting mixed up to some extent in the boring tools. But they no more vitiate the conclusions drawn from a general agreement of a number of sections than those slight variations allowed for on the score of "errors of experiment" in experimental science invalidate the conclusions drawn from a general agreement of results. In some instances, moreover, we have more definite data than a mere boring can furnish. At Brookwood, for example, the six-foot well with iron-cylinders was carried down to a depth of 197 feet, that is to say, through the whole of the Bagshot series and into the London Clay; at Wellington College the six-foot well penetrates about 180 feet; in the Ascot deep-well mentioned above the shaft or well extends down to 250 feet; and in the deep well at Wokingham the six-foot "dry-sinking" was carried down to 264 feet, that is, into the Basement-bed of the London Clay.

IV.—Notes on the Discovery of the base of a Large Fossil Tree at Clayton.

By S. A. Adamson, F.G.S.

ONLY a short time since there was discovered in the Lower Coal-measures at Idle, a magnificent specimen of *Megalichthys Hibberti;* and now, at Clayton, near Bradford, has been found one of the grandest examples yet seen of a fossil *Sigillaria* tree. It was in the Fall Top Quarry, at Clayton, worked by Messrs. Murgatroyd and Sons, that this remarkable fossil was discovered, and these gentlemen deserve the highest praise from all geologists for the skill and extreme care with which they have bared the fossil, and also for their kindness in allowing it to be inspected. This quarry is not far from the edge of a bold escarpment overlooking the Thornton Valley, and the well-known Elland Flagstone is worked here for landings, flags, etc. Between the Better-Bed-Coal and the Flagstone there is a great thickness of sandstones, shales, etc., of various characters, and it was in these measures that the fossil tree was discovered about 12 feet below the surface. The sandstones just referred to are of little commercial value, many being irregularly bedded, and others very perishable in their nature; the better kinds are used for rough walling, the remainder being merely rubbish to fill up other excavations. The marketable flagstone is at a considerable depth in this quarry, and blasting operations have to be carried on to remove rapidly the overlying strata. After one of these explosions, Messrs. Murgatroyd observed part of a large fossil tree exposed, and, profiting by their knowledge of geology (which, by the work of the Yorkshire Geological Society and also of the Leeds Geological Association, is rapidly spreading throughout the entire county), they immediately suspended further operations, and, instead, gave orders to their workmen to carefully bare the remainder of the roots. Part of the stump and four of the roots were damaged by the explosion, but four roots were left *in situ*. Since then, the broken pieces have been collected and placed together most admirably, presenting now the remarkable sight of a huge stump of Sigillaria, sending out eight forked stigmarian roots. The following dimensions, carefully measured, will afford an idea of the magnitude of this fossil:—

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[1] Cf. Proc. Geol. Association, vol. ix. No. 5.

	ft.	in.
Height of stump	3	9
Diameter of stump (longest axis)	4	6
,, ,, (at right angles to longest axis)... ...	3	10

Root.	Diameter close to stump.	Distance from stump to bifurcation ,of roots.	Distance from point of bifurcation to present termination of root.		Greatest length of root.
			Right fork.	Left fork.	
No.	inches.	ft. in.	ft. in.	ft. in.	ft. in.
1	21	4 0	9 6	13 0	17 0
2	17½	4 0	8 0	6 6	12 0
3	16	5 0	7 0	4 0	12 0
4	16	4 0	2 0	4 6	8 6
5	17½	7 0	1 6	3 0	10 0
6	18	5 6	3 0	4 6	10 0
7	17	7 6	3 0	2 0	10 6
8	17	7 0	9 6	7 0	16 6

The diameter of the visible area covered by the ramifications of the roots, is, from north to south, 29 ft. 6 in. and from east to west 28 ft., giving a superficial area exposed of 826 feet. The stump of the tree was embedded in soft sandy shale, locally termed "yellow loam," the roots resting on a bed of soft blue shale, which some of them penetrate. The roots 7 and 8, and also the roots 1 and 2, respectively cross each other, producing depressions in the lower roots at the point of contact. The Stigmarian roots present very finely the characteristic pits or scars from which the rootlets or filaments formerly originated, and an examination of the shale immediately touching the roots, reveals these rootlets in vast numbers. The neighbourhood appears to be prolific in grand examples of Carboniferous vegetation, for in another part of the quarry at a short distance, I observed two large stigmaria protruding from the side, whilst in the cutting of the railway close by, a good, but much smaller specimen of Sigillaria, with roots attached, was carefully got out, and presented by the engineer to the Yorkshire College at Leeds. So remarkable a fossil as the one described should be procured at once for one of our museums; it would be an unrivalled example for geological students. To allow it to meet the common fate of many fine fossils, that of being broken up for rockeries or gardens, would be an act of inexcusable and gross scientific vandalism. The proprietors intend, although it stops the progress of their business, to allow it to remain undisturbed for three or four weeks longer, and to any geologists tempted by the breezy Yorkshire hills and fine scenery, they offer a hearty Yorkshire invitation to inspect this giant fossil.

NOTICES OF MEMOIRS.

I.—SHORT NOTICES OF SCIENTIFIC PAPERS.

1.—Bibliothèque Géologique de la Russie, rédigée par S. Nikitin. Large 8vo. pp. 126. (St. Petersburg, 1886, Librairie Eggers et Cie.)

THIS work is intended to be a record of all books, periodical publications, and brochures treating of the geology, mineralogy, and palæontology of Russia, whether published in that country or elsewhere. It gives a short *résumé* of the contents of each work in Russian and French. The present is the first memoir of the series, and contains references to 256 separate papers which have been published in 1885. They appear to have been very carefully prepared, and in the palæontological papers the names of the new genera and species are quoted. There is also a complete index. This record will be of special value to all geologists, to whom at present works published in Russian are quite unavailable, for it will at least furnish an idea of the progress of the science in that country, and we sincerely hope that it may be continued in future years.

Annalen des K. K. Naturhistorischen Hofmuseums; redigirt von Dr. Franz Ritter von Hauer. Bd. i. No. 2. (Wien, 1886.)

This second number of the Annals of the new Natural History Museum at Vienna contains amongst others, the following important papers:—

2.—Ueber die miocenen Pteropoden von Œsterreich Ungarn, von Ernst Kittl. Mit einer lithogr. Tafel.

The characters of the minute and delicate shells of Pteropods from the Austro-Hungarian Miocene strata are carefully worked out, and illustrations given of most of the species. Their presence in great numbers indicates, according to the author, the abyssal character of the deposit. The following new species are described: *Creseis Fuchsi*, *Vaginella Lapugyensis*, *V. austriaca*, *V. Rzehaki*, *Balantium Fallauxi*, *B. Bittneri*, *Hyalæa bisulcata*, *Spirialis Kœneni*, *S. Tarchanensis*, and *S. Andrussowi*.

3.—Ansichten ueber die palæozoischen Insecten, und deren Deutung; von Prof. Dr. Friedrich Brauer. Mit zwei photozinkogr. Tafeln.

This is an elaborate critical review of the classifications adopted by Scudder, Brongniart, and others, for Palæozoic insects, and of the significance of the characters on which these have been based. In many points the author disputes the views of Scudder, lately published in Zittel's Handbuch der Palæontologie. The wing-structures of many of the Palæozoic insects and of their nearest living allies are well illustrated in the accompanying plates. Amongst other conclusions, the author states that the Palæozoic insects present no contradiction to the views of biologists as to the origin of the class, and that they did not form a special order which could be regarded as a general basis for the existing orders of insects.

4.—Bestimmung des specifischen Gewichtes von Mineralien, von Dr. Victor Goldschmidt.

The author points out the causes for the differences occurring in the practical determination of the specific gravity of the same mineral; which rest not so much in the method adopted as in the selection of the materials which are tested. G. J. H.

II.—NOUVELLES OBSERVATIONS SUR DES TRACES D'ANIMAUX ET AUTRES PHÉNOMÈNES D'ORIGINE PUREMENT MÉCANIQUE DÉCRITS COMME "ALGUES FOSSILES." Par A. G. NATHORST. Avec 5 planches en phototypie et plusieurs figures intercalées dans le texte. Kongl. Svenska Vetenskaps-Akademiens Handlingar, Bandet 21, No. 14. (Stockholm, 1886.)

THIS memoir is intended as a reply to the objections raised by the Marquis of Saporta and MM. Lebesconte and Delgado, to the opinions previously published by the author, that many of the supposed fossil algæ are in reality nothing more than the tracks of animals, or phenomena of purely mechanical origin. The fossils, whose nature is thus contested, are commonly known as *Cruziana,* or *Bilobites, Harlania, Eophyton,* and some other genera. They generally present themselves in demi-relief on the *under* surface of the beds in which they occur; no traces of organic substances are found associated with them, and they are composed of the same minerals as the matrix in which they are imbedded. The theory of their vegetable character rests on the peculiarity of their markings, which are supposed to be incapable of being produced by the tracks of organisms. Dr. Nathorst, however, shows very conclusively, that whilst it is difficult to understand how algæ could thus form casts in demi-relief on the under surface of the beds, such structures would be the natural result of the filled-up tracks or burrows of marine organisms. Of the *manner* in which these could be made, the author gives practical proof by passing a movable roller, shaped like a double spindle, over the surface of a layer of soft mud, and then by means of gypsum obtaining moulds of the concave impressions. Photographs of these moulds are given in the accompanying plates, and they faithfully represent in almost every detail, the supposed algæ. The author by no means denies the probable occurrence of true Algæ in Palæozoic strata, though he considers that most of the forms described as such by Saporta have no claim to be included in the vegetable kingdom. G. J. H.

III.—On the Flora of the Cromer Forest-Bed. By Clement Reid, F.G.S. Transactions of the Norfolk and Norwich Naturalists' Society, vol. iv. pp. 189—200.

FROM various exposures of the so-called Cromer Forest-Bed at different localities on the coast of Norfolk, and at Pakefield in Suffolk, Mr. Reid procured samples of dark peaty sandy clays, which by careful manipulation and washing, yielded the seeds and fruits of a number of plants. These were patiently and carefully picked out under a magnifying glass, classified, mounted, and then compared with existing forms, with the results that the number of species in the accompanying list is more than double that previously known. The species of Mosses and *Chara* have not yet been determined, but the list includes 40 species of *Dicotyledons*, 18 of *Monocotyledons*, 5 *Gymnosperms*, and 3 *Cryptogams*. With a few exceptions the same plants still exist in the locality, but some are locally extinct. Mr. Reid points out the significance of this fact, when it is considered that since the period when the plants lived whose fruits and seeds have been preserved, the Glacial epoch has intervened, and the large mammals, and even many of the mollusca, have become extinct. So far the investigations into the Pliocene Flora show that the period of intense cold produced but little effect in the distribution of the plants in this locality, since the same forms with few exceptions returned, apparently without intermixture, to re-occupy their former habitats.

The paper is a brief one, but it represents a great amount of steady, continuous work, and careful observation. It will prove of much value, both from a botanical as well as a geological point of view, and its importance is enhanced from the fact, that with one or two unimportant exceptions, no Plant-remains are yet known from other Pliocene beds in Britain. G. J. H.

REVIEWS.

I.—Department of the Interior. Report of the United States Geological Survey of the Territories. F. V. Hayden, United States Geologist-in-Charge. Volume III. The Vertebrata of the Tertiary Formations of the West. Book I. By Edward D. Cope, Member of the National Academy of Sciences. (Washington, Government Printing Office, 1883.)

IN recent scientific history of civilization few administrative events can compare in magnitude, or in their effects upon the populations concerned, with the Geological Survey of the United States. In no other part of the world have the resources of the Government been used with a like wisdom and liberality in accumulating and diffusing natural knowledge of the country, for the benefit of the people. It is impossible to express too strongly admiration for the administrative discernment which has recognized that organized knowledge of the geographical, geological, botanical, zoological, and anthropological conditions of the newly-settled lands of the West, is the necessary foundation for their commercial, social, and political prosperity. But when we contemplate the library in which the achievements of this great conception stand recorded, with all the elaboration which the best science of our time could command, we yield homage to those who have planned and have carried out this work, for a service to their country and to humanity, which in its way has no parallel.

The branches of science are so interrelated, that none can be said to be less or more important than the others. And if to the popular imagination geology and palæontology do not seem quite so engrossing as other matters among life's interest which develope from them, as a foundation, it is manifest that they have engaged the enthusiasm and life-long labour of intellects among the most remarkable which modern times have produced. And the great American Republic may be congratulated on having commanded the services of men of genius, whose courage and industry have been equal to grappling with this gigantic work.

The latest of the United Survey Reports, by Professor Cope, issued as a first part of a brief history of the fossil remains of Vertebrata, found in the Tertiary rocks of the Western Territories, extends to more than a thousand quarto pages of text, illustrated with some woodcuts and one hundred and thirty-four quarto plates, and gives in a noble and connected form a panorama of the life which the author had studied during the preceding ten years. Professor Cope's previous contributions to the same series of publications have prepared us for these matured studies, which are well described by Major Powell, the Director of the United States Geological Survey, as a "valuable contribution to palæontology, and a monument to the labour and genius of the author."

Professor Cope is a naturalist in the largest sense of the term; not undervaluing the great results which reward the comparative anatomist, but conspicuous among those who have cherished the traditions of zoologists, he has known well how higher results depend upon detailed work, and clear, full, and accurate description of the variable elements in organic structures. No man has a keener appreciation of the order of nature; and it is manifested again and again in new grouping, or the definition of new groups, or the intercalation of new types in their places among well-known tribes,—a power which is rare, because it can only flow from a knowledge of the extent to which the structures of any extinct type may vary, consistently with the preservation of its group plan, or the elimination from that plan of a series of characteristics. The gifts and attainments in which the analytical and synthetic powers are evenly balanced, and by which the extinct and existing life have been examined by the same methods, have long made the author of this work conspicuous as one of the most successful palæontologists who have yet adorned the science.

The volume now noticed is conceived in a systematic spirit. After the preface, which accounts for the origin of the collections, states the rules of nomenclature, and the chief scientific results attained, an Introduction describes the geological succession of Tertiary rocks of Western America, and attempts to correlate, on the evidence of their fossils, the American rocks which contain vertebrata, with those of Europe. If we do not discuss this correlation, it is because it raises questions which would require a volume for their examination; but we may say that just as the occurrence of fossil reptiles in America nearly allied to those in some European strata seems to us insufficient to fix the age of the American deposits; so the presence in American strata of extinct species of European genera of Mammals, even when many occur in common, is but uncertain proof of identity in age between the subdivisions of the American Tertiaries and the subdivisions recognized in Western Europe. But if this problem, which is taken up as it were by the way, is not finally solved, facts enough are presented to challenge attention, and justify the correlations which are made.

The first part of the volume discusses the Puerco, Wasatch, and Bridger groups of American fossil vertebrate life. The oldest of these is regarded as Tertiary, rather than as Post-Cretaceous. It is a lower division of the Wasatch series, with a distinct fauna, accumulated in the Wasatch Lake. The Wasatch beds range from New Mexico through Colorado and Wyoming, and consist of sandstones and marls, which vary from fifteen hundred feet to five thousand in thickness. Very few vertebrate fossils are found in the overlying Green River beds; but the Bridger group which succeeds has yielded a rich fauna, though the beds are less widely distributed than the older Eocene series.

The fauna of these beds comprises first, a large number of Fishes, which are observed to have a facies similar to that of the existing fresh waters of the United States, with the addition of two families now confined to the southern hemisphere. Among the Fishes we note a new Elasmobranch genus, *Xiphotrygon*, which is the genus *Trygon* with the teeth of *Raja*. The Lepidosteus type is represented by the extinct genus *Clastes*, of which four species are indicated. *Pappichthys*, another genus of these beds, differs from the existing *Amia* in having one, instead of several rows of teeth on the bones about the mouth, but though founded on mandibles, some of the species are described from vertebræ. The genus *Rhineastes* is a type of doubtful affinity, characterized by possessing vomerine teeth, and well known from five species. *Dapedoglossus* is a genus with four species closely related to *Osteoglossum*. *Diplomystus* comprises five species of Herrings, which differ from the genus *Clupea* in possessing small dorsal scutes in the median line of the back. The Perch type is represented by several genera, defined by the author under the names *Erismatopterus*, *Amphiplaga*, *Asineops*, *Mioplosus* and *Priscacara*. Of these genera, perhaps the most interesting is *Mioplosus*, which is allied to *Lebrax* and *Perca*. This fish fauna has more than ordinary interest from its occurrence in beds which yielded the higher vertebrata. Of Batrachia, the only Tertiary specimen known is from the Green River beds, and belongs to a tailless Batrachian, but too imperfect for description.

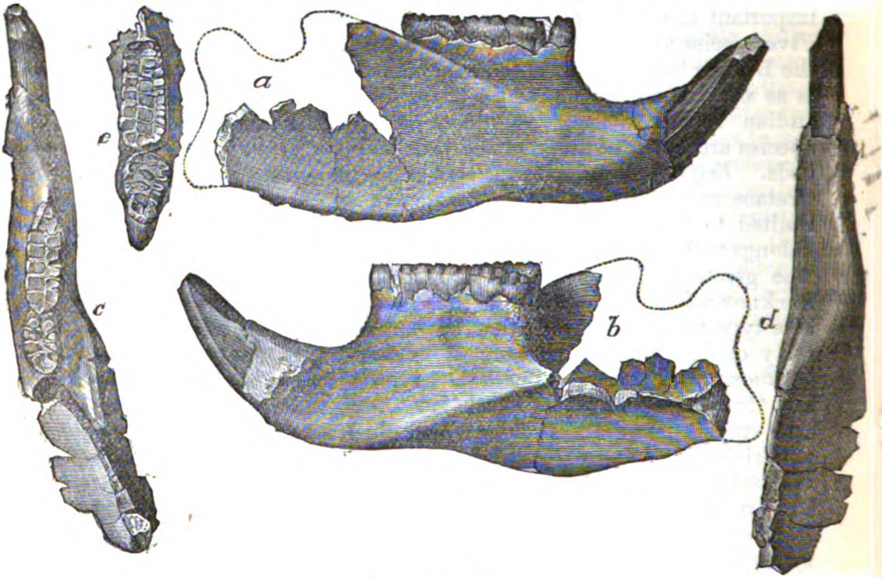
The Reptilia of American Eocene age are in no way remarkable except for the appearance of new genera. The Crocodilia differ in no important character from existing species of the genus *Crocodilus.* Five species are found in the Wasatch beds, and six other species in the Bridger beds. Seven species are here described: one, *C. heterodon,* is as small as an Iguana, while *C. clavis* is equal to the largest East Indian species. The Testudinata are more numerous. Sixteen species are found in the Wasatch beds and thirty-two in the Bridger beds. *Emys, Trionyx* and *Plastomenus* are genera surviving from the Cretaceous period, while six new genera appear, of which five are limited to these deposits. The new genera include *Axestus,* which belongs to the Trionychidæ, *Anostira* of Leidy, *Hadrianus, Notomorpha.* The genus *Emys* is represented by eleven species. The Lacertilia are known from three species of *Champsosaurus,* especially interesting as a type which survives from the Cretaceous Laramie formation. Only one Serpent is known; it is referred to an extinct genus *Protagras.* After the remarkable reptile fauna of the Laramie and Cretaceous rocks, this reptile fauna may seem tame; but any one who studies the beautiful plates which illustrate it will find abundant materials for philosophic study among the narrow-nosed Crocodilia, the variously-modified Tortoises, and the vertebræ of *Champsosaurus.*

Turning to the Mammals, Professor Cope reminds us that the Mammalia, like the Reptiles of the Permian epoch, have the family types in the Eocene rocks of America all more generalized, and that the orders are not so sharply differentiated from each other as in the later periods of the earth's history. The contribution therefrom which America now furnishes to our knowledge of the Mammalia is one of the most interesting chapters in the history of the group.

The story begins with the Marsupialia. This is one of the most difficult groups to define accurately on account of the strong insectivorous strain of characteristics which is so often present among fossils. But among genera which are more definite in their affinities is the remarkable genus *Catopsalis,* a rodent-like type with the jaw inflected as in the Kangaroo and Kangaroo Rat, but with a tuberculated Mastodon-like molar dentition. *Ptilodus* is another interesting Marsupial, remarkable as representing the Purbeck *Plagiaulax* in the American Eocene, though the affinity is not of a distant kind.

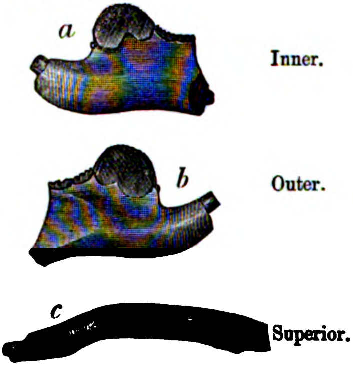
Passing to the Rodentia, the representatives are again few. They are apparently allied to the Squirrels, and are referred to five species of the genus *Plesiarctomys,* a well-known type in the Eocene of France.

The next order is termed Bunotheria. It is defined as having the animals armed with claws, with a transverse mandibular condyle, the molar teeth usually tubercular, and with incisors in the premaxillary bone. There are usually five digits, and commonly a third trochanter to the femur. It comprises all those animals which the author had at various times referred to the groups Creodonta, Mesodonta, Insectivora, Tillodonta and Tæniodonta, tribes which are now regarded as suborders of the Bunotheria. The group is almost as varied as the Marsupialia, and is regarded as a generalized type in which the relationships are not all with the smooth-brained mammalian orders, but quite as close with the Gyrencephala. The Creodonta are thought to be the ancestors of Carnivora, while the Mesodonta are probably ancestors of the Prosimiæ, and the affinity between the Prosimiæ and the Carnivora is considered as established. The Tæniodonta have Rodent-like inferior incisors, but also possess inferior canines. Each molar has a simple conical fang, and the enamel



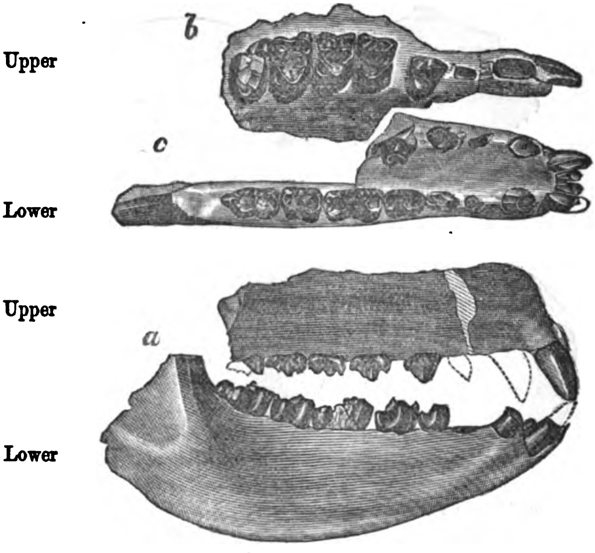
Catopsalis pollux.

a Right ramus external.
b Right ramus internal.
c Superior view.
d Inferior view.
e *Polymastodon taoensis*, possibly molar teeth of *Catopsalis.*



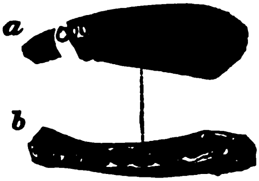
Ptilodus mediævus.

round it combines to suggest the characters of an Edentate. So that *Calamodon* is thought to furnish a hint of the relationship of the Edentata to other Mammals. *Tæniolabis* is a genus of allied character, founded on a single tooth. The Tillodonta is a suborder with rodent-like incisor teeth; and this character distinguishes the group from the Insectivora, to which the molar teeth approximate. There are three genera in this suborder. *Psittacotherium* has six inferior molars with cross crests, which with wear assume the form of the letter B, with the convexities turned forward. The incisor teeth are powerful and adapted for breaking nuts or cutting fruits. Two species are known. The other genera of this group have no representatives in the Wasatch and Bridger faunas. The Insectivora, which alone survive at the present day of all the Bunotheria, are well represented by the genera *Conorycthes* and *Esthonyx*. *Esthonyx* approximates to the Tillodonta in having the enamel of the incisors restricted in the lower jaw to the front of the tooth. The lower molars closely resemble those of the Hedgehogs, but several affinities are seen with Lemurs like *Chiromys*, and with the genus *Pelycodus*. *Conorycthes* has two inferior incisors, and is represented by several species. *Esthonyx* has three inferior incisors. It is remarkable for having the scaphoid and lunar bones separate, which is not the case with existing Hedgehogs. Four species are known. Another Bunotheroid suborder is named *Mesodonta*,—animals characterized by approaching the Quadrumana in proportions, but the rami of the mandible are separate, so that they also approximate towards Lemurs. Several allied forms occur in the Eocene of France, and it gradually became manifest that these

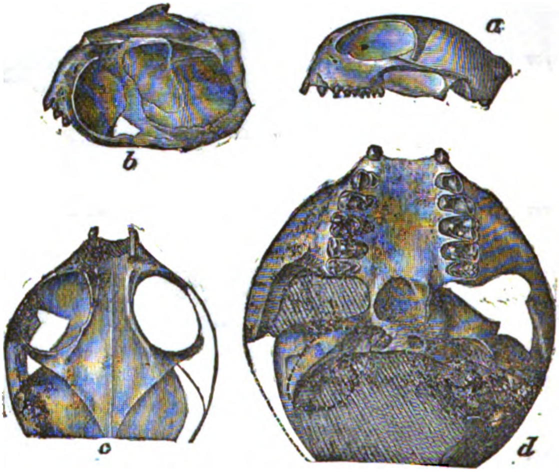


Esthonyx Burmeisteri.

animals differ, more than was at first supposed, from existing types. But the author is unable to separate the group from the Insectivora by ordinal characters. Eleven genera are comprised in this tribe, among them being *Microsyops* with two species; and *Tomitherium* closely allied to *Adapis* of Cuvier, but having two incisor teeth instead of three. *Tomitherium* is an animal with slender limbs and elongated femora, and the limbs generally have much of a quadrumanous character, and these resemblances are supported by those of the lower jaw and teeth; but in the form of the humerus there is resemblance to Lemurs. The only species is *T. rostratum*. *Pelycodus* is distinguished from *Tomitherium* by having the third trochanter in the middle of the shaft; and it has two roots to the second premolar. Other characters are shown in five species described. *Sarcolemur* is an allied genus, distinguished by having acute cusps on the heels of the true molar teeth. *Hyopsodus* is known from the mandibles of five species, and is distinguished by the simple inner tubercle, with cusps at the angles of the heels of the molars.



Hyopsodus vicarius.
a. Premaxillary and maxillary. *b.* Mandible.

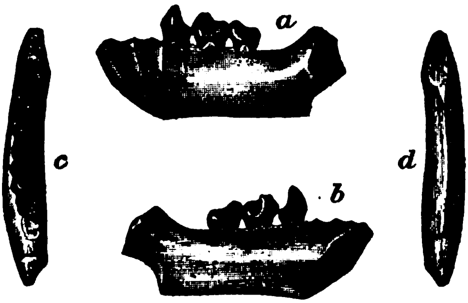


Anaptomorphus homunculus. Nat. size.
a, b. Side views. *c.* From above. *d.* From below.

The Prosimiæ are distinguished from the Mesodonta by having an opposable hallux which does not exist in the genus *Pelycodus*. The author states that *Chiromys* represents a primary division of the

Bunotheria, with a position between the Prosimiæ and the Tillodonta. There are probably three families of these Eocene Lemuroids, but there is some uncertainty as to whether the allies of *Adapis* belong to this or to the preceding group, so that the author limits his description to the Mixodectidæ and the Anaptomorphidæ.

Mixodectes is only known from mandibles, so that some uncertainty exists as to its systematic position as well as its dental formula, and the anterior teeth may be incisor, canine, and premolar, or the incisor tooth may be absent. Two species are known. *Cynodontomys* is also founded on mandibles; and *Anaptomorphus* complete the family. The latter genus, of which we give figures of the natural size, has large well-defined orbits. There is no sagittal crest, and the temporal ridges are well defined. In many ways the cranial characters approximate towards the Lemur *Tarsius*, yet the dental formula agrees with the Indrisinæ, but no known Lemur has premolar teeth with similar interior lobes and cusps, which resemble those of the higher Monkeys and Man. The small size of the canines is quite human. The cerebral hemispheres and brain are not smaller than in the genus *Tarsius* or in typical existing Lemurs. From the way in which quadrumanous and definite lemuroid characters are combined, the author suggests that this type may represent the family from which true Monkeys and Men were developed. The European type which most closely resembles this is *Necrolemur*; but in that genus the two inferior premolars have but one root. *Anaptomorphus æmulus* was about as large as a Marmoset. *A. homunculus* is founded on the cranium. It was rather smaller than *Tarsius spectrum*, and is thought to have been nocturnal; with feeding habits like the smaller Lemurs of the Malay Islands and Madagascar.



Anaptomorphus æmulus. Left mandible twice nat. size.

The Creodonta is a large division of Mammals with the scaphoid and lunar bones separate, narrow cerebral hemispheres having very large and exposed olfactory lobes; while the ankle joint is generally not trochlear. The separation of the scaphoid and lunar bones in the carpus is a distinction from the Carnivora, yet the articulation of the lower jaw with the squamosal bone is transverse, as in Carnivores. The ilium is suggestive of the Insectivora and Marsupials. The femur has a third trochanter. The astragalus articulated with the cuboid and navicular bones. There were five toes on the hind feet, in which the terminal digits are compressed and sharp. On the whole, in the limited number of incisor teeth it approaches the Insectivora; it has many affinities with the Prosimiæ and some affinities with Lemurs, and is more distantly connected with the Carnivora. The Creodonta differed from the Carnivora in the small size of the limbs as compared with the head. Many of the species are thought to have been aquatic. In Europe the group is represented by such types as *Arctocyon*, which has commonly been regarded as a Marsupial. In this suborder six families are included, comprising about twenty-seven genera. Among these genera the author would look for the ancestors of the existing Carnivora. The genera with marked inner cusps and tubercles to the molar teeth are nearest to the Marsupials. The genera without internal tubercles to the molars are regarded as ancestors of the Hyænodontidæ; the family Miacidæ are the forerunners of the Dogs; and the family Oxyænidæ were the forerunners of the Cats. It will thus be seen that this large group is worthy of careful study. The genus *Ictops* agrees closely with *Didelphys*; but there are only three upper incisors, and the angle of the mandible is not inflected. *Peratherium* agrees in dental characters with *Didelphys*, and is only retained until the complete dentition is known. *Triisodon* is characterized by the simplicity of the fourth inferior premolar, and the rudimentary anterior cusps of the molar teeth; from a study of its teeth the author concludes that the posterior milk molar of Diphyodonts is a permanent tooth in the Marsupialia. Four species exemplify the characters of this type. *Deltatherium* is a genus which has in the lower jaws two tubercular sectorial teeth, and a third behind them with a long heel. It has three premolars and a well-developed canine. The dentition is similar to that of the Opossums. *Didelphodus* differs from *Deltatherium* in having an additional premolar in the lower jaw.

Stypolophus is represented by ten species. *S. viverrinus* is about the size of the domestic Cat. Its skull is remarkable for the lachrymal bone not extending posterior to the large lachrymal foramen. The genus is found in the Phosphorites of France, but the author does not follow Gaudry in uniting it with *Proviverra*, because the fourth upper premolar has an internal cusp and an external cusp, flanked in front and behind by a basal heel.

The Miacidæ comprise two genera, *Miacis* and *Didymictis*. *Miacis* is conspicuous for its canine characters, among which marsupial affinities are said to be no more prominent than in the case of other Creodonta; while *Didymictis* makes an approximation towards *Oxyæna* in its dentition. It is well represented by seven species. The Oxyænidæ comprise *Pterodon*, *Protopsalis* and *Oxyæna*. Characters of the skull are suggestive of Cats, but the head was larger and limbs smaller than in true Carnivora, and they rather resemble the Carnivorous Marsupials in proportions. This type is supposed to have been aquatic. *Mioclænus* comprises about eight species, known from their dentition, which affiliates the genus to *Arctocyon*; but it is distinguished by the single tubercle on the inner part of the crown of the upper molars. Enough of the skeleton of *M. ferox* is known to show that its nearest living ally is probably *Thylacynus;* but it differs from Marsupials in having a patella. It is about as large as a Sheep. The remaining American genera of Creodonts are *Dissacus, Sarcothraustes* and *Mesonyx.* The latter genus has some resemblance to *Hyænodon,* but more to *Amblyctonus.* The claws are flat like those of Seals; but the structure of the ankle suggests that the type was not exclusively aquatic. *Mesonyx* is thought to have lived on Turtles.

M. ossifragus was as large as a large-sized American Black Bear with the fore-limbs much shorter than the hind-limbs, giving much the aspect of a huge Rabbit, except that the tail was long. It was one of the largest Eocene flesh-eaters.

In this review we have attempted to give some idea of the varied organization comprised in the Bunotheria. The conception of this group is the most original contribution to mammalian classification which has been made for a long time. The group is almost as difficult to realize, as would be a conception of the Marsupialia, if Marsupials were only known in a fossil state. Some exception may be taken to the term order, by which the Bunotheria is indicated, for the group is rather a lower division of the placental subclass; which the author would compare to the Marsupialia in the variety of organization it includes, while he believes it to have developed simultaneously with the Marsupials, or even to have been an older group. The classification has necessarily grown out of the affinities which the described families of Mammals have with each other, rather than with surviving groups; and although we cannot pronounce a decided conviction on the importance of this great generalization without an examination of the specimens on which it is founded, the principles on which it is evolved are sound. If we recognized the Creodonta and other groups as allied to existing orders of Mammals, but distinguished by their smaller brains, and less specialized organization, then the existence of the Bunotheria becomes not only a convenience in classification, but a generalization which will direct research.

H. G. SEELEY.

(*To be continued.*)

II.—CATALOGUE OF THE BLASTOIDEA IN THE GEOLOGICAL DEPARTMENT OF THE BRITISH MUSEUM (NATURAL HISTORY), WITH AN ACCOUNT OF THE MORPHOLOGY AND SYSTEMATIC POSITION OF THE GROUP, AND A REVISION OF THE GENERA AND SPECIES. By ROBERT ETHERIDGE, Jun., and P. HERBERT CARPENTER, D.Sc., F.R.S., F.L.S. 4to. pp. xiv. and 322. Illustrated by Twenty Lithographic Plates and Twelve Woodcuts. (London, 1886, Printed by Order of the Trustees.) Price 25s.

WE know not whether it be due to the beneficial effects of transplantation, but there has certainly been a steady issue of publications in connection with this Department since its removal, in 1880, from Great Russell Street, Bloomsbury, to the new soil of Cromwell Road.

A penny Guide to the Geological Galleries appeared on their re-opening to the public on 19 April, 1881, followed by an illustrated edition in 1882 (price threepence); a third followed in 1884; and a fourth edition (price fourpence) in 1886. Of the three earlier editions altogether 11,234 copies have been sold. A Guide to the Fossil Fishes appeared in 1885 (price threepence). A Catalogue of the Fossil Foraminifera, by Prof. T. Rupert Jones, F.R.S. (8vo.), appeared in 1882 (price 5*s.*). A Catalogue of the Fossil Sponges, by Dr. G. J. Hinde, F.G.S., 4to. with 38 plates (price 30*s.*), in 1884. A Catalogue of the Fossil Mammalia (8vo.), Part I., by Richard Lydekker, B.A., F.G.S., was issued in 1885 (price 5*s.*, with thirty-three woodcuts); Part II. also in 1885 (price 6*s.*, with thirty-nine woodcuts); Part III. in 1886 (price 4*s.*, with thirty woodcuts); (Part IV. we are informed is now passing through the press). A Catalogue of the Palæozoic Plants in the Geological Department, by Mr. R. Kidston, F.G.S. (8vo. pp. 288, price 5*s.*), appeared in 1886.

The present work was commenced by its authors some years since, but their task was delayed by the necessity to collect materials which might serve to illustrate in detail the minute structure of this curious and extinct group of Echinodermata. They were soon fortunate in obtaining the co-operation of Mr. Charles Wachsmuth, of Burlington, Iowa, a gentleman who has devoted some twenty-five years to the collection of Crinoidea from the Carboniferous rocks of North America, and who has also published several important memoirs on these organisms. With his aid, and that of numerous other friends in Europe and America, the authors have been enabled to examine probably the largest and most instructive collection of these organisms ever brought together, thus rendering the comprehension of their minute anatomy comparatively easy, and giving one confidence in the interpretation which they offer of each detail of their structure.

With regard to the systematic position of the BLASTOIDEA, one of the authors (Dr. P. Herbert Carpenter) has had peculiar advantages in approaching the subject, from his previous studies of the Crinoidea collected by the "Challenger" expedition; whilst both authors have long and patiently studied the fossil forms, and have endeavoured by the examination of numerous remains and by the preparation of very many sections, exhibiting internal structure, accurately to work out the morphology of this obscure and but little understood group.

The position of the Blastoidea in relation to the rest of the Echinodermata has long been a subject of grave discussion; but the leading authorities are now agreed in giving the Blastoids a position as a group equivalent in rank to the Brachiate Crinoids and the Cystids, or to the Urchins and Starfishes.

Blastoids with stems appear to be extremely rare, although there is little doubt that the great majority were stalked forms. Indeed the authors figure several examples (see plate iii. fig. 16; pl. v. fig. 25; pl. vi. fig. 23; and pl. xvi. fig. 7) showing the remains of stems. But the stem in *Granatocrinus* is of moderate size compared to the diameter of the flat basal disc of which it occupies the centre. In *Pentremitidea*, *Orophocrinus*, *Cryptoblastus*, and *Troostocrinus* the basal cup is elongated and tapers elegantly downwards until its narrow lower end rests directly upon the first stem-joint, which is sometimes seen still united to the base. One Pentremite has been obtained by Mr. Wachsmuth, in which the stem terminates below in a branching root like that of the *Bourgueticrinidæ*: whilst three genera of Blastoids, namely, *Pentephyllum*, *Eleutherocrinus*, and *Astrocrinus*, appear to have had *no stem* in the adult state, whatever may have been the case during their early life.

The following definition of the PELMATOZOA[1] (under which name the stalked Echinodermata are classed by the authors) will probably give the leading characters of this difficult group more clearly than any words of our own :—

"Phylum ECHINODERMATA, Branch PELMATOZOA. Echinoderms which are fixed either permanently or temporarily by the middle of the aboral surface. A jointed stem containing a neuro-vascular axis is usually present, but may be lost when maturity is reached; or, in the case of a few sessile forms, remain altogether undeveloped. The apical system consists of a dorsocentral plate, basals, and radials, with the frequent addition of under-basals and interradials. These plates form a cup, which either simply supports, or more or less completely encloses, the visceral mass, and often bears jointed appendages—the arms and pinnules.

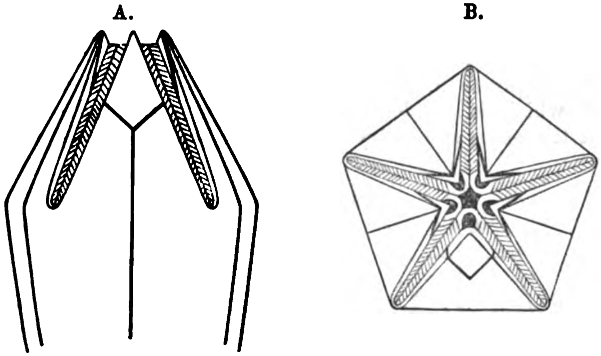


FIG 1.—Diagram of *Troostocrinus Reinwardti*. A. the anal side. B. the summit view. The radio-deltoid sutures are shown by rather darker lines.

"An oral system, which is to some extent a repetition of the apical system, and consists of a central plate, basals, radials, and interradials, is developed to a very variable extent above the actinal surface of the larva. It may be (1) altogether resorbed; (2) persist as basals only which cover the peristome; or (3) reach a high state of development so as to form a complex vault or *tegmen calycis* covering in the whole visceral mass. The anal tube opens on the oral surface, but is sometimes in close relation with the calyx-plates.

"The water-vascular ring does not communicate directly with the exterior, and the lateral branches of the radial vessels (when present) are respiratory, but not locomotor in function."

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[1] From πέλμα, πέλματος, stalked, and ζῶον, animal.

"Class Blastoidea.—Armless Pelmatozoa of a pyriform, clavate, ovate, or globose shape, which usually exhibit a very perfect radial symmetry. Base monocyclic, of two large plates and one small one, the latter being always in the left anterior interradius, Fig. 2. II. (A–B). Five radials, more or less deeply incised by the ambulacra, and five interradials which rest on them and bound the peristome, one of them being pierced by the anus. For view of summit, see Fig. 1, B. p. 421.

Ambulacra fringed on each side by a single or double row of jointed appendages, which are in close relation to the side plates. These rest on or against a subambulacral lancet-plate, which is pierced by a canal that lodged the water-vessel and unites with its fellows into a circum-oral ring.

Hydrospires arranged in ten (or rarely eight) groups which are limited to the radial and interradial plates; their slits are parallel to, and more or less completely concealed by, the ambulacra, often opening externally through pores at their sides, and also by five or ten openings round the peristome. Neither hydrospires nor ambulacra extend below the basiradial suture.

Peristome naturally concealed by a vault of small plates, which rarely exhibit any definite arrangement, and are continuous with the covering-plates of the ambulacra."

From the foregoing definition it will be seen that the Blastoids differ in certain important points from other Pelmatozoa, notably in the perforation of the lancet-plate, "of which we have as yet no knowledge whatever in either Crinoids or Cystids. The absence of under-basal plates and the constant presence of five interradials (one of which is divided in *Elæacrinus*), lastly the constant but peculiar trimerous symmetry of the base, only observed in the rare

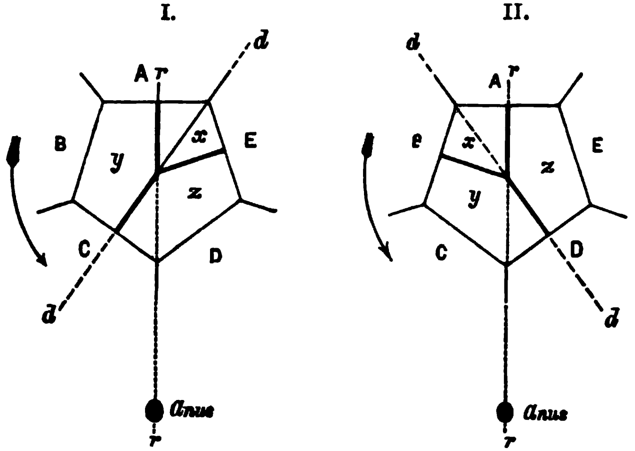

Fig. 2.—Diagram showing the arrangement of the basals in I. *Platycrinus*, and II. in the Blastoids. *A*, *B*, *C*, *D*, *E*, the five radii of the calyx. *x*, the small azygos basal. *y*, *z*, the two larger basals. *d* . . . . *d*, the dorsal axis. *r* . . . *r*, the radial axis, in which the anus is situated. The arrows show the (probable) direction of the spirally-coiled digestive tube.

Cystid, *Cryptocrinus cerasus*, and possibly in one Crinoid (*Stephanocrinus*). Many Palæocrinoids have a trimerous base, but according to Wachsmuth and Springer ("Revision of the Palæocrinoidea," pt. iii. 1885, p. 10), the small plate is always in the right anterior interradius (A—E). (See Woodcut, p. 422, Fig. 2, I.)

The calyx of many Blastoids is marked by very well-defined ridges, which start from the bottom of the basal cup and extend upwards until they meet the radial lips at the distal ends of the ambulacra. The general arrangement of these ridges is the same in all Blastoids, and is perhaps best studied in *Stephanocrinus* in which type they are very strongly marked (see Woodcut, Fig. 3, *infra*).

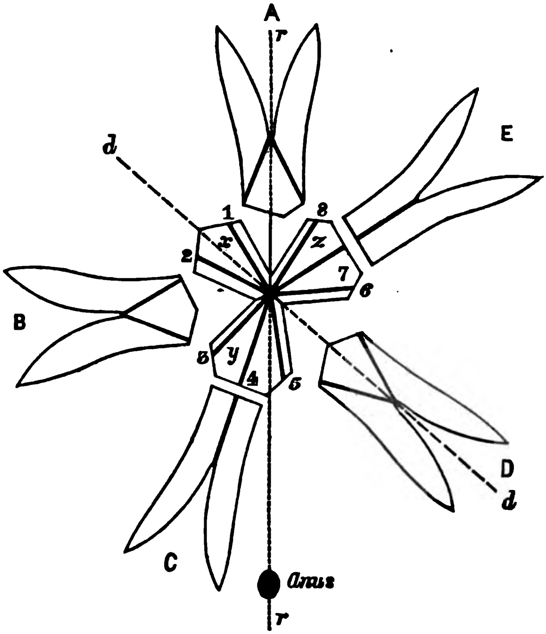

Fig. 3.—Diagram to show the position of the ridges (1-8) on the three basals and the five radials (*A, B, C, D, E*) of *Stephanocrinus angulatus* (modified from Roemer). (The lettering of the plates is the same as in Fig. 2.)

Lastly we may notice the very symmetrical grouping of the hydrospires. "These organs occur in most Cystids, and perhaps even in some Crinoids, but we know of no member of either group in which their arrangement is at all like that which occurs in the Blastoids. In this class they are restricted to the radial and interradial plates, where they lie with their slits parallel to the ambulacra, and except in the genus *Codaster*, there are always five interradial pairs of hydrospire-groups. No Cystid whatever presents anything like this regular distribution of the hydrospires, which often extend down on to the basals, and even on to the under-basals, when such are present."

"Considered as a whole, the Blastoids have the most regularly constructed calyx of any Pelmatozoa, and in fact of any Echinoderms. Under-basals may occur in all the brachiate forms, while the basals of Crinoids may vary in number from two to five, and the development of the interradials varies extremely among the different groups." (p. 119.)

There is a persistent number of thirteen plates in the Blastoids, with the single exception of *Elæacrinus*, which has the posterior deltoid divided into two by the anal plate; and with the exception of three genera, *Eleutherocrinus*, *Astrocrinus*, and *Pentephyllum*, the

ECHINODERMATA.		UPPER SILURIAN.	DEVONIAN.						CARBONIFEROUS.			
Branch PELMATOZOA. Class BLASTOIDEA.	No. of Species.	America.	America.	Britain.	Belgium.	Germany.	France.	Spain.	America.	Britain.	Belgium.	Germany.
Order REGULARES, E. and C.												
PENTREMITIDÆ, D'Orb.												
Pentremites, Say	49	...	...	...	..	...	...	...	*	...	...	...
Pentremitidea, D'Orb.	18	...	*	?	*	*	...	*	...	...	...	?
Mesoblastus, E. and C.	7	...	...	...	...	...	...	...	*	*	*	...
TROOSTOBLASTIDÆ, E. and C.												
Troostocrinus, Shumard...	2	*	...	?	...	...	?	?	?	...	...	...
Metablastus, E. and C.	7	...	...	?	...	...	?	?	*	...	...	...
Tricœlocrinus, M. and W.	5	...	...	...	...	...	...	...	*	...	...	...
NUCLEOBLASTIDÆ, E. and C.												
Elæacrinus, Roemer	9	...	*	...	...	...	...	...	...	...	...	...
Schizoblastus, E. and C....	10	...	?	...	...	...	...	...	*	*	...	...
Cryptoblastus, E. and C.	3	...	...	...	...	...	...	...	*	..	...	...
Acentrotremites, E. and C.	1	...	...	...	...	...	...	...	...	*	...	...
GRANATOBLASTIDÆ, E. and C.												
Granatocrinus, Troost	10	...	?	...	...		...	...	*	*	...	...
Heteroblastus, E. and C.	2	...	...	...	...	...	...	...	*	*	...	...
CODASTERIDÆ, E. and C.												
Codaster, McCoy	15	*	*	*	...	...	...	...	*	*	...	...
Phænoschisma, E. and C.	7	...	...	...	...	...	...	*	?	*	*	...
Orophocrinus, von Seebach	9	...	..	...	...	...	...	..	*	*	*	...
Cryptoschisma, E. and C.	2	...	...	...	...	...	...	*	...	...	...	...
Order IRREGULARES, E. and C.												
ASTROCRINIDÆ, T. and T. Austin.												
Astrocrinus, T. and T. Austin ...	2	...	...	...	...	...	...	...	...	*	...	...
Eleutherocrinus, Shum. and Yand.	3	...	*	...	...	...	...	...	...	...	...	...
Pentephyllum, Haughton	1	...	..	...	...	...	...	...	...	*	...	...
Total	162											

contour of the calyx is always perfectly symmetrical, consisting as it does of five equal and similar radials, and five deltoids of the same nature.

The foregoing table (from p. 136) is extremely valuable as showing the Distribution of the Genera of the Blastoidea in Space and Time. We have added a column with the probable number of species referred to each genus.

From the foregoing list, it will be seen that only two (American) generic forms, *Troostocrinus* and *Codaster*, occur in the Upper Silurian, about six or seven genera in the Devonian; whilst the great majority occur in the Carboniferous series both in England and in America.

A careful description of each species is given by the authors, illustrated by twenty quarto plates and 399 figures, most beautifully and accurately drawn by Messrs. C. Berjeau and P. Highley, requiring not only great artistic power, but a large store of patience in making out such minute and very elaborate details.

All Biologists who are interested in the Echinodermata must feel grateful to the authors of this very elaborate and exhaustive Memoir, which clears up so many points in the anatomy of this ancient class, that has hitherto been but very imperfectly understood.

We trust they may be so well satisfied at the favourable reception which this volume is sure to meet with, that they will take up and work out in the same earnest and painstaking manner the still more important and interesting Brachiate division, which has remained far too long neglected by palæontologists.

III.—CATALOGUE OF THE FOSSIL MAMMALIA IN THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W. PART III.[1] CONTAINING THE ORDER UNGULATA, SUB-ORDERS PERISSODACTYLA, TOXODONTIA, CONDYLARTHRA AND AMBLYPODA. By R. LYDEKKER, B.A., F.G.S., etc. 8vo. pp. xvi. & 186. (London, 1886, printed by Order of the Trustees.)

THE present part of Mr. Lydekker's Catalogue of the Fossil Mammalia completes the order UNGULATA with the exception of a single group, the PROBOSCIDEA. This group, it is announced, will form Part IV. of the Catalogue, which is now in the press. Although embracing only a small section of the Mammalia, this part is of special interest to the palæontologist; for out of the eighty species recorded in its pages, all are extinct save four, namely, *Tapirus Americanus*, *Equus caballus*, *Rhinoceros sondaicus* and *Rh. unicornis*. Furthermore, of the seventy-eight extinct species, no fewer than thirty-two species, belonging to as many as twelve genera, date back to the Eocene Tertiary formation, namely, *Lophiodon* (5 species); *Hyracotherium* (3 species); *Pachynolophus* (4 species); *Palæotherium* (8 species); *Anchilophus* (2 species); *Rhinoceros* (2 species); *Cadurcotherium* (1 species); *Periptychus* (1 species); *Haploconus* (1 species);

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[1] Part II. was noticed in the GEOLOGICAL MAGAZINE, April, 1886, pp. 175-177.

Coryphodon (1 species); *Tinoceras* (2 species); and *Dinoceras* (2 species)—represented in the collection.

The genus *Lophiodon* nearly approaches the Tapir and Rhinoceros in the structure of its teeth. Like the Tapir the lower true molars have simple transverse ridges, but the premolars are more or less longitudinally tuberculated, and in this respect it differs from its near ally, the *Palæotherium*, in which the whole series of the lower molars are longitudinally bi-crescentic in form. It had also, like the Tapir, which it preceded in geological time, four toes on the fore-feet and three on the hind-feet.

Many species are enumerated, ranging in size from the Pig to the Rhinoceros. Their remains have been met with in several localities in Europe, and also in this country, in Eocene Tertiary strata.

Its dentition may be expressed as follows:—

Incisors $\frac{3}{3}$, canines $\frac{1}{1}$, premolars $\frac{3}{3}$, molars $\frac{3}{3}$, $\times 2 = 40$.

Hyracotherium was a small animal, about the size of a Hare, principally known in a fossil state by its dentition. Its remains are comparatively rare and have been found in the Lower Eocene (London Clay), Herne Bay; at Kyson in Suffolk; and also as a derived fossil from an older deposit in the Suffolk Crag.

Pachynolophus is an allied genus of small animals, whose remains are only found in Eocene deposits. Four species are represented in the collection by teeth and jaws from France and Switzerland. The dentition is *complete*, viz.:—

Incisors $\frac{3}{3}$, canines $\frac{1}{1}$, premolars $\frac{4}{4}$, molars $\frac{3}{3} \times 2 = 44$.

Palæotherium is well represented in the collection. It was a Tapir-like animal, first described by Cuvier, from skulls, teeth and bones, of numerous individuals, representing several species, which were discovered in the Gypsum quarries (Upper Eocene) of Montmartre, Paris.

Palæotherium magnum was as large as a Horse, four or five feet in height; whilst *P. curtum* was about the size of a Hog. They all had a short fleshy snout or proboscis, like the Tapir; but, unlike the Tapir, they had only three toes on each foot, whilst the Tapir had four toes on the fore-foot.

Mr. Lydekker (following Prof. Flower) treats *Paloplotherium* as identical with *Palæotherium*. *P. annectens* was about the size of a Sheep and is well represented in the collection from the Upper Eocene of Hordwell, Hants, and from Vaucluse in France.

Anchilophus, a small Palæotheroid, is represented by jaws and teeth from the Upper Eocene at Bembridge, Isle of Wight, and from Vaucluse and Caylux in France.

The Rhinoceroses are now all placed in a single genus, which includes five or six known living species. No fewer than twenty-four species are represented by fossil remains in the collection, mostly from Pleistocene, Pliocene or Miocene Tertiary deposits; but two forms, *Rh. croizeti* and *Rh. lemanensis*, occur in the Upper Eocene phosphorites of France, thus carrying this remarkable living genus back in time to the older Tertiaries. Four other genera, of which at present we possess only imperfect materials for study, are provisionally referred to the family *Rhinocerotidæ*, namely: *Hyracodon*, *Cadurcotherium*, *Homalodontotherium* and *Elasmotherium*. Of these four genera, one only (*Cadurcotherium*) dates back to the Eocene period.

Periptychus and *Haploconus* are both Lower Eocene genera from New Mexico in North America. They are characterized by the grooved and ridged sculpture of the teeth. They form a part of the suborder CONDYLARTHRA, in which are placed a number of those primitive Mammals having a bunodont or lophodont type of cheek-dentition, foreshadowing both the Artiodactyla and Perissodactyla; there are usually five digits in both the manus and pes, the terminal phalangeals being acuminate. The best-preserved example of the family is the genus *Phenacodus*, of which a figure was given in the GEOLOGICAL MAGAZINE for February, 1886 (Plate II. p. 49).

Under the suborder AMBLYPODA is placed the remains of the genus *Coryphodon*, from the Lower Eocene of Harwich, Essex, and from Dulwich, near London. It also occurs in the Eocene of France and North America.

Coryphodon was the largest of the early Eocene Ungulates, and the relative smallness of its brain, together with its five-toed feet, which resemble in structure those of the Dinocerata, indicate some affinity to that group, which it also preceded.

The section DINOCERATA is included in the same suborder, and completes the series of Eocene Mammals represented in the collection.

We are indebted for our very perfect knowledge of the genera *Tinoceras* and *Dinoceras* to Professor O. C. Marsh, whose labours in exploring the Eocene Tertiary deposits of the Wyoming Territory have opened up an entirely new chapter in Tertiary palæontology.

For a full account, with figures, of these interesting genera, see the GEOLOGICAL MAGAZINE for May, 1885, Decade III. Vol. II. pp. 212–228 (with 18 Woodcuts).

The fore and hind limbs had feet with five well-developed toes, each terminating in a hoof; the femur and tibia were placed vertically in a line, as in the hind-leg of the Elephant. The nasal bones were elongated, having two small pre-nasal bones in front of them; the animal does not appear to have been furnished with a proboscis.

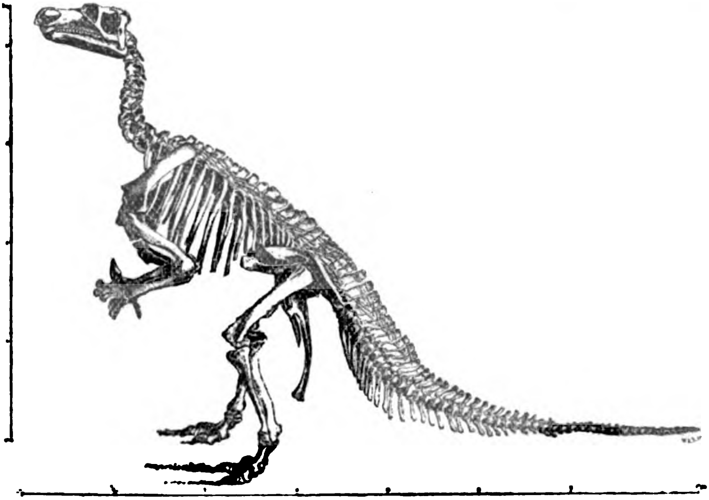
The most striking feature is the skull, which is surmounted by three pairs of rounded protuberances or horn-cores, which were probably enveloped in horny sheaths. There are no upper incisors, but the upper canines are developed into large and powerful flattened tusks, directed downwards, and protected on each side by the broadly-expanded margin of the lower jaw.

These early Eocene types have so important a bearing upon the question of the derivation of our existing Mammalian fauna, that we cannot but welcome every addition to our knowledge concerning them, and we have to thank Mr. Lydekker for this further instalment of his Catalogue, and to express the hope that we may soon have it before us in its completed form.

IV.—British Museum Guide to the Department of Geology and Palæontology. 4th Edition. (1886, Printed by Order of the Trustees.)

In this neat little volume (which contains 117 pages of text and 49 excellent woodcuts) the amateur palæontologist can obtain for the small consideration of fourpence a concise synopsis of the chief divisions of the Animal Kingdom. The greater portion of the book, which has been written by Dr. Henry Woodward, F.R.S., Keeper of the Department, with the aid of his valuable Assistant the veteran Mr. William Davies, F.G.S., of the same Department, is devoted to the Vertebrata, and since the Fossil Fishes have been treated of in a separate 'Guide,' attention is mainly concentrated on the Mammalia, Aves, and Reptilia; the Amphibia coming in for a more limited notice. The Mammalia are divided into the following 12 orders:—Primates, Carnivora, Insectivora, Chiroptera, Dermoptera (*Galeopithecus*), Rodentia, Ungulata, Sirenia, Cetacea, Edentata, Marsupialia, and Monotremata. By far the largest space is assigned to the Ungulata, which is split up into the Proboscidea, of which the Museum contains the finest collection in the world; the Hyracoidea, at present unknown in the fossil state; the Amblypoda, containing the *Coryphodon*; the *Dinocerata*, represented by a fine series of casts presented by Prof. O. C. Marsh; the *Condylarthra*, a primitive group of five-toed forms from the Eocene of N. America; the *Toxodontia*, which includes the peculiar Rodent-like *Typotherium* of S. America; the Perissodactyla; and the Artiodactyla. We may especially notice in this order the excellent figures illustrating the difference in the structure of the molars of the African and Indian Elephants, and also those showing the characteristic dentition of the existing *Hippopotamus* and of the extinct species from the Siwalik Hills of India. A special feature in the Ungulate collection is the series of skulls of the peculiar group of ruminants from the Pliocene of India and Greece, comprising the *Sivatherium*, *Bramatherium*, *Hydaspitherium*, and *Helladotherium*, which appear to connect the modern Deer with the Antelopes, and are more or less closely related to the existing Giraffe. The Museum possesses the type skull of the first-named genus, while of the second and third genera casts of the skulls have been respectively procured through the courtesy of the Council of the Royal College of Surgeons and the Director of the Geological Survey of India. Full justice is also done in the work to the splendid collection of Edentata from the Post-Tertiaries of South America, and of Marsupials from those of Australia; and we are glad to notice a good figure of Sir R. Owen's *Tritylodon* from the Secondary strata of South Africa, for which we believe Dr. Woodward is indebted to the courtesy of Prof. E. D. Cope, of Philadelphia. The remarkably fine skeleton of Steller's Sea-Cow (*Rhytina*), which was recently acquired for the Museum, is also figured, and compared with that of the existing Manate. Seven pages are devoted to the class Aves, and include figures of *Archæopteryx*, *Hesperornis*, *Odontopteryx*, and *Dinornis*. Save in the table of contents, no mention is, indeed, made of the subdivisions of the class, and this is perhaps wise, since it is very difficult to make its divisions accord in importance with those of the other vertebrate classes; we think, however, that it will be advisable eventually to rank the divisions of Carinatæ, Ratitæ, and Saururæ as orders, and to relegate to the rank of suborders the so-called orders into which the Carinatæ are divided by students who confine their attention to existing forms.

Pages 70 to 87 are assigned to the Reptilia, and we note with satisfaction the classification which has been adopted in this difficult class, as being one of the best that has come under our observation. The orders adopted are the Pterosauria, Crocodilia, Dinosauria, Anomodontia, Ichthyosauria, Ophidia, Lacertilia, Plesiosauria, and Chelonia. The divisions of the second order proposed by Prof. Marsh are adopted with a subordinal value; while the Anomodontia includes the Theriodontia, Dicynodontia, Rhynchocephalia, Cryptodontia, Endothiodontia, and Placodontia. According to this arrangement it will be necessary to retain Prof. Dollo's group of the Simædosauria for *Champsosaurus*, since that genus seems more distinct than *Endothiodon* from the typical Rhynchocephalia; we should, however, have preferred to have placed the last-named genus in closer proximity to that suborder. In the Lacertilia the *Mosasauridæ* are ranked merely as a family, which avoids the necessity of the introduction of Prof. Cope's Pythonomorpha. In this class there are figures of *Rhamphorhynchus*, *Pterodactylus*, *Dimorphodon*, *Iguanodon*, *Megalosaurus*, *Ichthyosaurus*, *Plesiosaurus*, *Megalania*, and *Chelone*.



Skeleton of *Iguanodon Bernissartensis*, Boulanger (restored after Dollo) from the specimen in the Brussels Museum.

The Invertebrates occupy pp. 92-107, but as the notice of these classes is necessarily brief, we need not refer further to them on this occasion. The last page of the text mentions the extensive collection of Fossil Plants, which is not yet arranged; and also calls attention to the valuable series of type collections now in course of arrangement. Since the latter includes the collections of Dr. William Smith, Mr. S. V. Wood, J. and J. de Carle Sowerby, Mr. F. E. Edwards, and Dr. Thos. Davidson, their interest to all palæontologists must be of the greatest. The volume concludes with an excellent plan of the Palæontological Galleries and a well-arranged Index.

With the publication of this series of popular "Guides" for the nonscientific, and of the "Catalogues" for the scientist, the British Museum is rendering its unrivalled collections of the best possible advantage to all classes of visitors; and we beg to offer our hearty congratulations to Dr. Woodward and his able coadjutors on the successful completion of the present "Guide" to one of the most interesting branches of the whole collection.

REPORTS AND PROCEEDINGS.

ZOOLOGICAL SOCIETY OF LONDON.

June 29th, 1886.—Osbert Salvin, Esq., F.R.S., V.Pres., in the chair.—The following communication was read:—

"Note on the Presence of a Columella (Epipterygoid, Parker) in the skull of *Ichthyosaurus*," by A. Smith Woodward, F.G.S. Communicated by the President.

In this paper, the author recorded the presence of a "columella" (epipterygoid) in the skulls of several Liassic Ichthyosaurs in the British Museum, and offered a brief account of the main features of the bone. The communication was suggested by Sir Richard Owen's statement ("Foss. Rept. Lias Form." p. 96) that he had observed no trace of the element in question in the British fossils; and the fact became still more worthy of note, since Prof. Cope (Proc. Amer. Assoc. Adv. Sci., vol. xix. p. 200) had already determined the presence of a columella in the skull of an American Ichthyosaur, and this circumstance was evidently overlooked by Sir Richard Owen. As pointed out by Prof. Cope, the bone is long and slender, with expanded extremities; and in the present communication the author showed that it was a distinct element, although a suture at its upper end in the American specimen appeared to be wanting. It was further remarked that the lower extremity of the Ichthyosaurian columella exhibits a striking resemblance to its homologue in *Sphenodon*, in the fact that the expansion shows two distinct articular facettes upon its inner aspect as is well seen in the specimen figured in Hawkins' "Book of the Great Sea-Dragons," pl. 19, fig. 1. In the living Rhynchocephalian genus, the articulation is contracted both with the pterygoid and an inward extension of the quadrate; in *Ichthyosaurus*, however, its nature cannot yet be determined, and, according to Prof. Seeley, there is no inwardly-directed process of the last-named bone.

ERRATUM.—GEOL. MAG. August, 1886, p. 341, legend to woodcut, for "Interior," read *Exterior*.

ON THE TERM NEOCOMIAN.

Sir,—When my article on the use of the term Neocomian appeared in this Magazine, I felt conscious that I had provoked a formidable antagonist, and when I saw Prof. Judd's long letter in the July Number, I felt like the captain of a frigate about to receive the broadside of a three-decker; but it seems to me that the utmost damage I have received is a few shot through my sails, and that the hull of my little vessel is left perfectly water-tight.

A large part of Prof. Judd's letter is devoted to showing that I was mistaken in crediting him with being the first to apply the term *Neocomian* to British strata, and he says that the author who had the chief honour (as he esteems it) of introducing that term was the late Mr. R. A. Godwin-Austen. Well, this is perfectly true. I admit that Godwin-Austen was the first to use the term; in 1843 he employed it for what we now call the Atherfield Clay of Surrey, and in 1856 he speaks of the "Lower Greensand or Neocomian group;" but in the first paper (Proc. Geol. Soc. vol. iv.) he correlated the Surrey clay with the *argile ostréenne* of the Vassy section, and in the second he makes the Lower Greensand of North Wilts correspond with the *Urgonien* of D'Orbigny. Now subsequent researches proved these correlations to be erroneous. Renevier and Marcou, writing in 1856 and 1858, showed that the English Lower Greensand was not the equivalent of the *Neocomien* or of the *Urgonien*, but of the *Rhodanien* and *Aptien*; consequently the use of the term in England, having originated in a mistake, ought to have been abandoned.

So indeed it might have been but for the intervention of Prof. Judd, who is certainly responsible for its revival in 1864, and for urging its more extended application in 1870. His article "On the use of the term Neocomian" (Geol. Mag. Vol. VII. p. 220) was written with the special object of recommending the adoption of the term for the whole series of beds between the Gault and the Jurassic strata, and of raising this series to the rank of an independent system. I maintain therefore that if Prof. Judd had not introduced this name for the second time, it is highly probable that it would never have found a place in British nomenclature.

Prof. Judd next refers to Godwin-Austen's arguments for the Neocomian age of the Lower Greensand fossils. I repeat that by the increase of our knowledge these arguments have been shown to be fallacious; of course the fossils of the Lower Greensand resemble those of the Urgonien more than those of the Gault and Chalk! if it were otherwise, we should class the Lower Greensand with the Upper and not with the Lower Cretaceous rocks. If Prof. Judd cannot formulate a better reply to the arguments adduced by me on p. 318 of this Magazine, I think I may look upon my case as proved.

I am told that "scientific names go through a struggle for existence," and that the fittest survive; maybe they do, but in my opinion the name Neocomian is not yet out of the struggle, and has not yet definitely found its proper place. Surely, Sir, geology is a rapidly progressive science, and our nomenclature is always undergoing modification; old names must sometimes be limited or dropped, and new names must be created as the progress of knowledge demands. Why in point of fact Prof. Judd and I are actually discussing the desirability of dropping an old name (Lower Greensand), and of finding another to take its place; he prefers to borrow a foreign term and to extend its application; I point out the objections to this plan and prefer to use a new name altogether. Let us argue the matter clearly and fairly, and then leave the readers of this MAGAZINE to decide between us, but I do not see why my opponent should deprecate the idea of my "formulating a new nomenclature" for the Cretaceous rocks either in my private or official capacity.

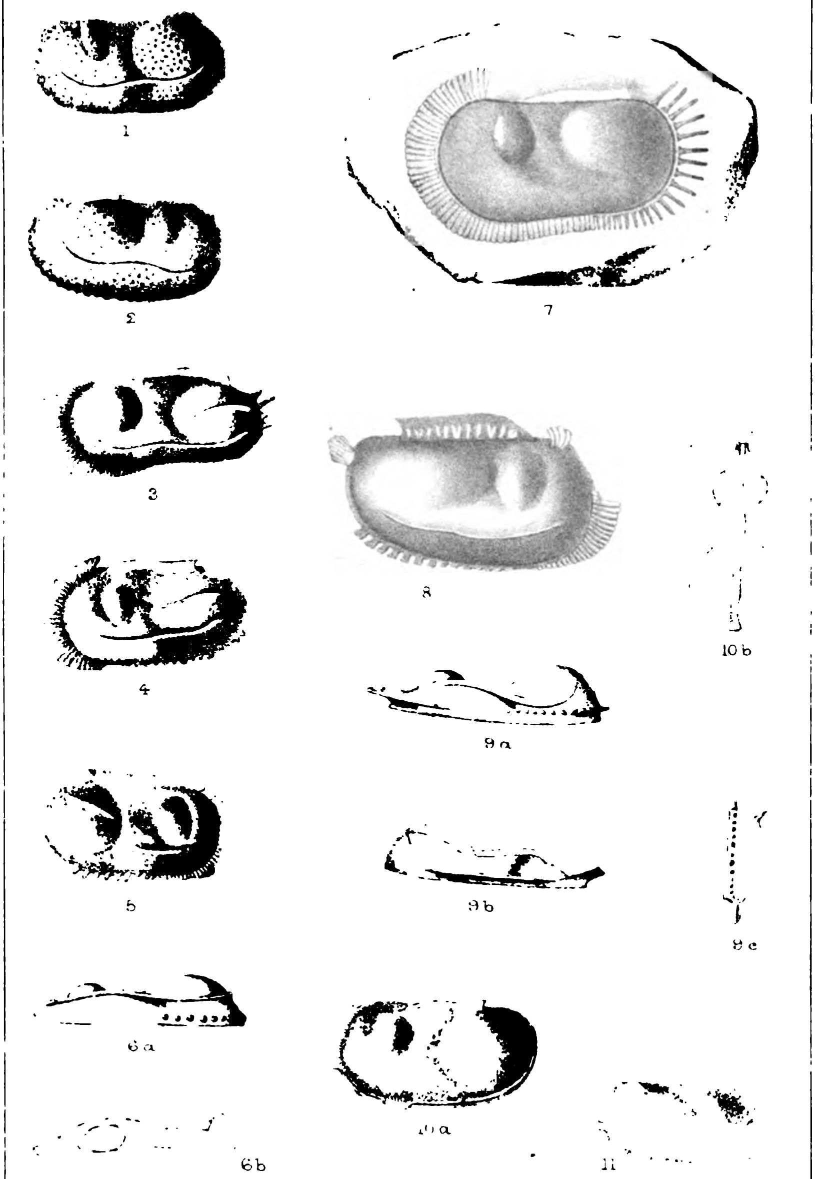
Lastly, let me offer Prof. Judd my hearty thanks for drawing my attention to the passage which he quotes from Dr. Fitton, and which I had been careless enough to overlook. I am delighted to find myself anticipated by so great a master as Fitton, and to be relieved of the responsibility of introducing a new name; it is remarkable that Fitton should have foreseen the very want which has since arisen and I feel that I shall have a much stronger case in referring to the term *Vectine* or *Vectian* as his proposal, suggested in 1845, and revived by myself in 1885. A. J. JUKES-BROWNE.

August 10.

ON A REMARKABLE SECTION IN DERBYSHIRE.

SIR,—During the meeting of the Warwickshire Field Club at Matlock, we visited a remarkable sandpit at Longcliff, four miles S.W. of Matlock Bath, on high ground near Brassington. Our attention was drawn to this by Mr. Howe, of Matlock, as one of the most interesting geological features of the district. The section exhibits a series of variegated and highly coloured sands and clays, here and there containing a few pebbles of small size, chiefly of white quartz and in places lignite. These are not pebble-beds at all resembling the ordinary 'Bunter pebble beds,' nor do I remember any Bunter section showing such a peculiar succession of variegated sands and clays. They lie in a trough or hollow of the Carboniferous Limestone, and there are several other smaller pits in the same neighbourhood and under similar conditions, though not sunk at present to any great depth; at Longcliff the total thickness is thirty feet. The sands and clays are of various colours, yellow, white and red, and in some cases a dark vermilion, giving a very remarkable appearance to the section. Lithologically they resemble the variegated sands and marls in the Tertiary (Middle Bagshot) series, especially at Alum Bay in the Isle of Wight; and the question is whether they should be assigned to the Bunter or the Tertiary, and if they should prove to belong to the later period, I believe it is the first remnant of the kind recognized in Derbyshire. The occurrence of lignite leads to the possibility of this deposit being of Tertiary age: but of course no absolute decision can be given without further investigation, which Mr. Howe has promised to undertake. This pit was opened after the visit of the Geological Survey to Derbyshire, so that the section was not exposed at that time. P. B. BRODIE.

Geol Mag 1886. Decade III Vol III. Pl XI.



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Carboniferous Ostracoda

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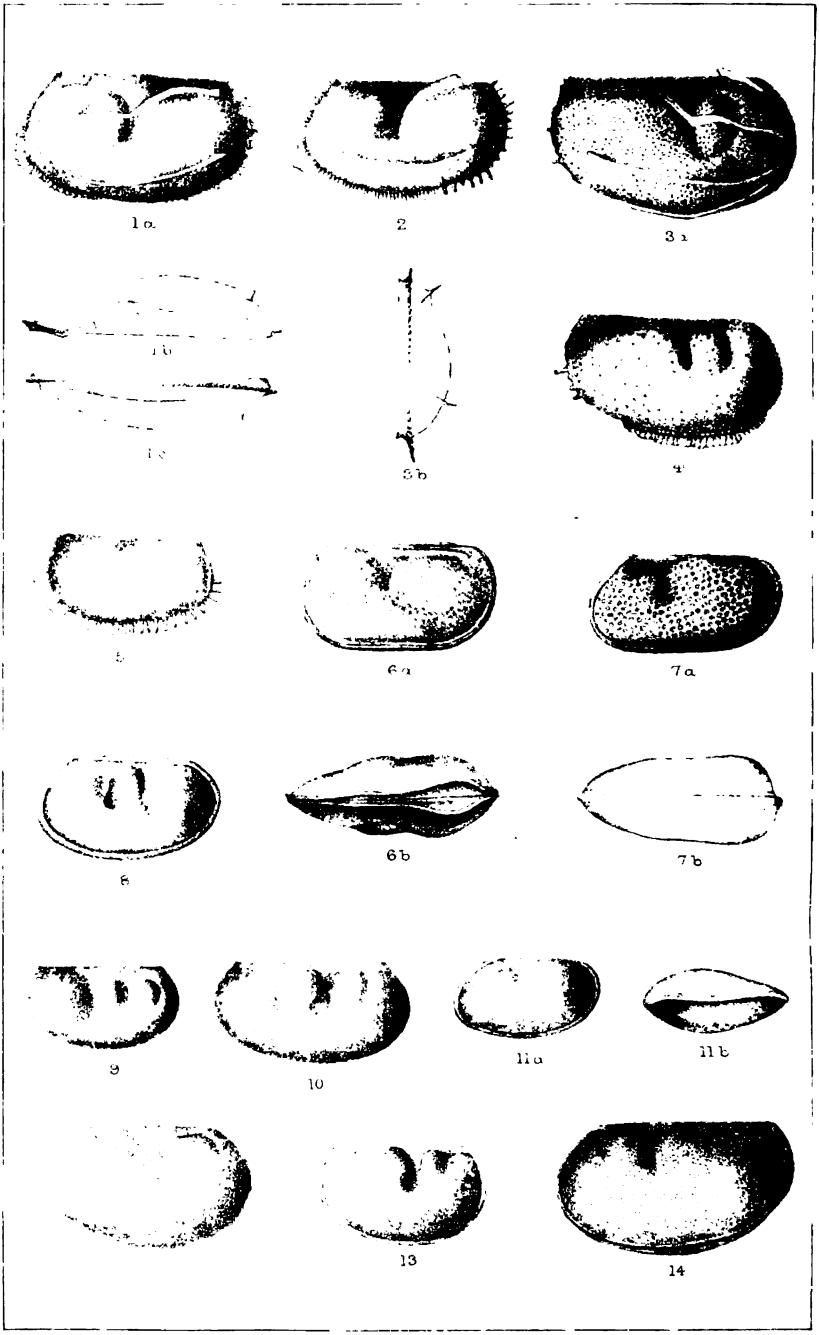

J.W.K. del.
E.C. Knight lith.
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Carboniferous Ostracoda.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. X.—OCTOBER, 1886.

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ORIGINAL ARTICLES.

I.—On some Fringed and other Ostracoda from the Carboniferous Series.

By Prof. T. Rupert Jones, F.R.S., and James W. Kirkby, Esq.

(PLATES[1] XI. and XII.)

A YEAR or two ago we received from Mr. James Bennie, of the Scottish Geological Survey, a washing of Lower-Carboniferous shale from Plashetts, Northumberland, which was very rich in the remains of Ostracods. Among other species occurring therein was a *Beyrichia*-like form, ribbed as in *Kirkbya*, and with a wide fringe about the free margins of each valve.

About the same time Mr. Bennie kindly sent us another washing from the Lower-Carboniferous series, Staneshiel Burn, Roxburghshire, containing numerous examples of similar fringed and ribbed carapaces.

Since then the same or nearly allied forms have been found by us in material from other localities, chiefly in the lower portion of the Carboniferous formation.

These forms, though evidently coming near to *Beyrichia* and *Kirkbya*, can scarcely be placed in either genus, and we propose to group them under the generic name of *Beyrichiopsis*.

With them we also place a fringed species (Pl. XI. Fig. 7) that several years ago we found in an impure limestone or cement-stone of the Calciferous Sandstone, at Billow Ness, in Fife. This species has been referred to by us as identical with or nearly allied to *Beyrichia crinita*, J. and K., in recent papers;[2] and it is evidently the same as one of the forms from Plashetts, though in a different state of preservation.

Lastly, we include *B. crinita* in the new genus, for, though as yet but imperfectly known, it is a fringed species, and thus nearest to the forms under notice.

Beyrichia radiata, J. and K., which has a curious marginal expansion or plate, somewhat akin to the fringes of the present species, we scarcely know what to do with, though we leave it in *Beyrichia*.

The following is a brief and provisional description of the genus.

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[1] These Plates have been drawn with the aid of a grant from the Royal Society for illlustrating fossil Ostracoda.

[2] Quart. Journ. Geol. Soc. vol. xxxvi. 1880, p. 567; and Proc. Berwickshire Nat. Club, vol. x. 1884, p. 323.

BEYRICHIOPSIS, gen. nov.

Carapace-valves outlined and lobed more or less after the fashion of *Beyrichia;* either unisulcate, with two roundish separate lobes, or with one subcentral and more pronounced lobe, defined by a faint sulcus on one side and a deeper furrow between it and the swollen posterior part of the valve. The anterior end rather the highest, as in *Beyrichia.* Two or more thin, curved or sinuous, outstanding ribs pass along the valves (as in some specimens of *Kirkbya*), one of which is usually placed near the dorsal edge and developed into a crest. The surface is smooth, punctate, or finely granulate. A broad, fimbriate or spinous fringe extends along and a little outside of the free margin of each valve; this and the ribs form the characteristic features of the genus, so far as known.

1. BEYRICHIOPSIS FIMBRIATA, sp. nov. Plate XI. Figs. 3–10, and Pl. XII. Fig. 5?

Valves ovate-oblong in outline, lobed, bearing two or more longitudinal ribs, and with the free margins curiously fringed and spined; height half the length, or less. The dorsal border is straight and nearly three-fourths of the valve's length; the ventral border is almost straight or slightly incurved; the extremities are rounded, the anterior being rather the highest. A large globose lobe or boss occupies the posterior third (or more) of the valve; a much smaller circular or ovate boss is dorsally placed near the anterior third; and a third, but slighter, swelling is sometimes developed in the ventral region between those already named. A thin lamella-like rib runs parallel and near to the dorsal margin; a shorter, though similar, rib is usually present along the middle of the posterior lobe; and a third (more or less sinuous) traverses the ventral region of the valve; all these ribs run out to nothing anteriorly, and end abruptly posteriorly, often with curved points. At the antero-dorsal angle of each valve, and a little outside of the exact margin, there commences a broad and delicate wing-like fringe, directed slightly outwards, and regularly marked with radiating lines or grooves. This fringe extends round the anterior extremity to beyond the centre of the ventral border, where (the groovings becoming more pronounced) it gradually breaks up into a series of flattened spines that extend, on the same plane, round the posterior extremity as far as the postero-dorsal angle. Seen from above or below, the carapace has a lobate-cuneiform outline, the anterior end being the thinnest, and the posterior almost symmetrically rounded. Surface apparently smooth. Length $\frac{1}{25}$ inch.

Examples of this species vary very little except in relative height and length.

The marginal fringe is never perfectly seen in testiferous examples, —as might be expected from its delicate character, the valves having lost it if at all knocked about before imbedment. Many specimens, however, show it more or less imperfectly, so that synthetically a very fair idea of it can be arrived at. At Billow Ness, where this species is abundant on certain planes of the cement-stone before mentioned, the external impressions of the valves show this feature very beautifully.

Pl. XI. Fig. 7 is an internal cast of a valve with the external impression of the fringe.

Fig. 8 is a very fine testiferous example, from Staneshiel Burn, with a well-developed and ornate crest, and a curious palmate spine (?) near the postero-dorsal angle.

This species is always found in deposits of marine origin. At Plashetts it is associated with marine fossils, besides other Ostracods in abundance, such as *Kirkbya costata, Beyrichia radiata, Leperditia Okeni, Cytherella valida,* etc.

At Billow Ness it occurs along with *Bellerophon decussatus, Murchisonia striatula, Leda attenuata, Sanguinolites abdensis,* etc., and with *Leperditia Okeni* and other Ostracods.

Pl. XII. Fig. 5 represents a fringed form from Cultra, County Down, Ireland, which probably belongs to this species, though the crushed state and general bad preservation of the specimens leave the reference doubtful.

Localities.—Calciferous-Sandstone series. Plashetts, Northumberland; Tweeden Burn, and Staneshiel Burn, Roxburghshire; coast to the west of Billow Ness, Fifeshire[1]; ? Cultra, County Down.

Carboniferous-Limestone series. Murrayfield Pit, Linlithgowshire; and Sunnybank Quarry, N.W. of Kirkcaldy, Fifeshire.

2. Beyrichiopsis fortis, sp. nov. Pl. XII. Figs. 1–3.

(Var. *glabra*, Figs. 1, 2; Var. *granulata*, Fig. 3.)

Another fringed form, nearly related to *fimbriata*, occurs in the Lower-Carboniferous Shale at Staneshiel Burn, Liddlesdale. It is larger than the latter, and, were it not for the marginal fringe and longitudinal ribs, would have a very Beyrichian style of valve. We have been in some doubt whether to consider it a variety of *fimbriata* or a distinct species, but adopt the latter view, and describe it as follows:—

Obliquely subovate, lobed, longitudinally ribbed, and with a marginal fringe; height less than half the length. Dorsal border straight and three-fourths of the valve's length; ventral border boldly convex; extremities rounded, but with well-marked dorsal angles, the anterior extremity oblique and larger than the other. The posterior half of the valve is swollen and forms a large rounded lobe, in front of which, and separated by a deep and narrow sulcus, is a small oval boss; the ventral portion of the valve is tumid. A thin, sinuous rib passes obliquely across the valve from near the antero-ventral angle diagonally upwards, terminating abruptly, with a downward bend, before reaching the posterior extremity; another long curved rib, commencing a little below the first, passes along the ventral portion of the valve; and occasionally another appears not far from, and parallel with, the ventral fringe; and near to the antero-dorsal angle there is a short, curved rib, sharply pointed behind. The free margin of each valve is ornamented with a radiating fringe (and spines) similar in character to that of *fimbriata*. The surface in Fig. 3 is granulated (var. *granulata*). Length, $\frac{1}{20}$ inch.

---

[1] The thin limestone or "cement-stone" at this locality is only about one foot thick. It is a compact and very hard grey stone, showing scarcely a trace of fossils as it occurs unaltered between tide-marks. A little higher up, where it runs into the soil and a recent shell-bed (old beach), it becomes decomposed, especially about the joints, and takes the character of a soft, yellow ochre, that is easily split up with a pocket-knife or needle. The rock is then seen to be literally full of the remains (casts or impressions) of Mollusca and the carapace-valves of Ostracods. The contrast of how much is to be seen in a piece of this rotten stone in comparison with how little in a piece of the unaltered stone is most surprising and very instructive.

Good examples of this species have a granulated surface, but some occur that are smooth (var. *glabra*, Figs. 1 & 2). In the latter state, and particularly when the valves are rather worn, or flattened by pressure, they simulate *Kirkbya plicata*, and are not always easy to be distinguished from it.

The ribs vary a little in development. The small one near the antero-dorsal angle is often absent; and that immediately below occasionally extends across only the posterior half of the valve.

This species is, as already stated, nearly allied to *B. fimbriata;* but differs from it in its larger size, less elongated form, more decided Beyrichian style of lobes, the granulated surface of its best form, and the absence of the dorsal rib or crest of that species.

Localities.—Calciferous-Sandstone series. Staneshiel Burn and Tweeden Burn, Roxburghshire.

3. Beyrichiopsis cornuta, sp. nov. Plate XI. Fig. 11.

From localities in the Carboniferous-limestone series (Lower) we have a third fringed Beyrichia-like form. It is smaller than the preceding species, has a spinose fringe all round the free margin, possesses no ribs, but in their place has one or two large spines or spikes projecting from each valve. Some of the specimens have only a spine on the large posterior lobe or boss; others have one on the anterior lobe as well. The surface is smooth; and the length is from $\frac{1}{30}$ to $\frac{1}{80}$ inch.

We name this form *cornuta*, and include it in *Beyrichiopsis* on account of its fringe.

It occurs at Linlithgow Bridge, Linlithgowshire; Woodend Quarry, Fifeshire; and Dun Quarry, Lowick, Northumberland.

4. Beyrichiopsis crinita, Jones and Kirkby.

Beyrichia crinita, J. & K. 1884, Proc. Berwicksh. Club, vol. x. p. 322, pl. ii. fig. 10, 11.

This species was described by one of us (from specimens collected by Mr. George Tate) in the Proceedings of the Berwickshire Nat. Club, as above quoted. We have nothing to add to this, as no additional specimens of it have been discovered. It is from the Lower Carboniferous rocks of Alnwick Moor, Northumberland.

Prof. Emmons notices and figures a fringed Beyrichian form from the Trenton Limestone, of New York State, in his "Manual of Geology," 2nd edit. 1860, pp. 95 and 100. Probably this may belong to our new genus.

5. Beyrichiopsis subdentata, sp. nov. Pl. XI. Figs. 1, 2.

Along with *B. fimbriata* in the Plashetts shale are numerous examples of another form, having longitudinal ribs, a reticulo-punctate surface, and occasional traces of denticles on the ventral and posterior borders.

It is smaller than *B. fortis*, but of similar outline, and with the valves lobed much in the same manner. A sinuous rib passes across the lower half of the valve concentric with the ventral and extreme borders; and a short dorsal rib is sometimes present on the posterior half. The surface is regularly, and somewhat coarsely, punctate, rather than reticulate. The posterior half of the free margin of some specimens is denticulated, but there are no traces of a fully-developed fringe. Length, $\frac{1}{27}$ inch.

We have examined many valves of this species, but can find nothing to show that it ever possessed a perfect fringe. The valves we meet with of *fimbriata* and *fortis* very often are without this appendage; but this is accidental, for close examination invariably shows where it has been broken off, by removal from the matrix or otherwise. In *subdentata*, however, the margins show no indication of fracture, and they are evidently found as they were originally.

Locality.—Calciferous-Sandstone series. Plashetts, Northumberld.

Neither of the last two species exactly agree with our definition of the genus: *B. cornuta* having the marginal fringe, but not the longitudinal ribs; *B. subdentata* possessing the latter character, but the fringe only in a very incipient state. Still we are inclined to look upon them as belonging to the same natural group as the others, though less advanced perhaps in the process of differentiation from *Beyrichia*. In fact, by taking another and less elastic view of the subject, it would be easy to look upon all the forms as but the varietal or individual differences of one species; for they certainly run very near to each other. This, however, would scarcely be in accordance with modern biological ideas; nor could we ignore the probability of the soft parts of the various forms having differed materially one from the other.

6. Beyrichiopsis simplex, sp. nov. Pl. XII. Fig. 4.

A very short time ago, Mr. Hugh Miller, of the Geological Survey, sent us a series of Ostracodous specimens from the Carboniferous rocks of Northumberland. Among them is a fringed form from the Lower Carboniferous of Warksburn, North Tynedale, that appears to be different from those already described. It occurs in single valves, imbedded in a matrix of dark grey shale, along with species *Kirkbya*, *Cytherella*, and other marine fossils.

It has a neat Beyrichian outline, with rounded extremities and a convex ventral margin. The anterior portion of the valve is much higher than the posterior. There is a well-marked subcentral sulcus, with a round, but rather faint boss in front. The surface has no ribs; but is sparsely and finely granulated. A narrow fringe bounds the free margin, and breaks up into spines posteriorly, as in other species; and at the base of the fringe runs a beaded line. Length, $\frac{1}{34}$ inch.

We name this form *B. simplex*. The full locality for it is "above Ramshaugh, Longlee Ford, Warksburn, North Tynedale."

BEYRICHIELLA, gen. nov.

There is another species (probably more than one) which comes near those described above, but which has no fringe, although it possesses a dorsal crest on each valve with a well-marked area between. It has a strong free-marginal overlap; and is quite unisulcate. This may be regarded as typical of a new genus and species under the name *Beyrichiella cristata* (Pl. XII. Figs. 6*a*, 6*b*).

This form is abundant in some of the shales and cement-stones of the Calciferous Sandstones in the East Neuk of Fife,—as at Randerstone and Billow Ness.

Note on some BEYRICHIÆ.

1. BEYRICHIA ARCUATA, Bean. Pl. XII. Figs. 12—14.

Cypris arcuata, Bean, 1836, Mag. of Nat. Hist. vol. ix. p. 377, woodcut, fig. 55.

B. arcuata was figured roughly by Bean in 1836; but, for the purpose of making comparison easy, we figure it here anew. It is a well-known and characteristic species of the Coal-measures proper, in some of the shales and ironstones of which it is found in great numbers.

It is comparatively large, being from $\frac{1}{20}$ to $\frac{1}{18}$ of an inch in length; subovate in outline, with convex valves; the dorsal margin is straight, the ventral margin arched; and the posterior end is the smallest (lowest). A deep sulcus marks the anterior half of the valves, and in front of it, close to the antero-dorsal angle, there is often a small, nearly obsolete notch, more strongly marked on internal casts. The valves are rimmed, and the surface is polished and finely punctate.

Among other localities, it occurs in Coal-measure strata at Ashby-de-la-Zouch; Agecroft Colliery near Manchester; Chesterfield; Ryhope Colliery and Claxheugh near Sunderland; and at Shotts and Carluke in Lanarkshire.

2. BEYRICHIA FASTIGIATA, Jones and Kirkby. Pl. XII. Figs. 8, 9, 10.

B. fastigiata, J. & K., 1867, Trans. Geol. Soc. of Glasgow, vol. ii. p. 220.

This species is smaller and has the valves more broken up into lobes than *B. arcuata*. Seen from above the outline is sub-cuneiform,—widest behind, pointed in front. The surface is punctate.

Length $\frac{1}{26}$ of an inch. It was discovered by Mr. John Young, F.G.S., of Glasgow.

It occurs in the Carboniferous-Limestone series at Bathgate (Linlithgowshire); Craigenglen, Campsie (Stirlingshire); Crossgatehall (Edinburghshire); East of St. Monans (Fifeshire); and in the Calciferous-Sandstone series West of Billow Ness (Fifeshire).

3. BEYRICHIA BRADYANA, sp. nov. Pl. XII. Fig. 11.

B. Bradyana is a small subovate form, with the left valve strongly overlapped by the right. It has a well-marked subcentral sulcus, and in some specimens a fainter and smaller anterior impression, with a roundish boss between. Seen from above, the outline is compressed-ovate, pointed at the ends. Surface smooth; length $\frac{1}{36}$ of an inch. Many specimens are relatively higher and shorter than the one figured. Discovered by Mr. John Young, F.G.S.

It is found in the Carboniferous-Limestone series at Charlestown, Sunnybank Quarry, and near St. Monans, in Fifeshire; at High Blantyre, Lanarkshire; and Whitebaulks, near Linlithgow.

4. **BEYRICHIA CRATERIGERA**, G. S. Brady, MS. Pl. XII. Figs. 7*a*, 7*b*.

Another species with a strong free-marginal overlap may be described thus. Obliquely oblong; equal in height, dorsal and ventral borders, being nearly parallel; extremities rounded, with a forward swing; a deep sulcus near the anterior third, and another passing forward to the antero-dorsal angle. Valves convex, the right overlapping the left very strongly; lateral contour cuneiform; shell thick; surface strongly reticulated. Length $\frac{1}{27}$ to $\frac{1}{26}$ inch.

This fine species was discovered by Mr. David Robertson, F.G.S., of Glasgow, in the Carboniferous-Limestone series, at Calderside Quarry, Lanarkshire; it also occurs in Lower-Carboniferous rocks at Woodend Quarry and Plashetts, Northumberland; and at Arnside, Westmoreland.

EXPLANATION OF PLATES.

PLATE XI.

(All the Figures, except Figs. 7 and 8, magnified 25 diameters.)

FIG. 1. *Beyrichiopsis subdentata*, J. and K.; left valve; 2, right valve. Plashetts.
,, 3. *B. fimbriata*, J. and K.; left valve; fig. 4, left valve. Plashetts.
,, 5. ,, right valve. Tweeden Burn.
,, 6*a*. ,, ventral edge of left valve; 6*b*. dorsal edge of right valve. Plashetts.
,, 7. ,, cast of left valve, with impression of its fringe; magnified 40 diameters. Billow Ness, Fife.
,, 8. ,, right valve; magnified 30 diameters. Staneshiel Burn.
,, 9*a*. ,, ventral edge of left valve; 9*b*. dorsal edge of left valve; 9*c*. hinder end view; *a* and *c* showing the fringe.
,, 10*a*. ,, carapace, showing left valve; 10*b*. dorsal view. Tweeden Burn.
,, 11. *B. cornuta*, J. and K.; right valve. Linlithgow Bridge.

PLATE XII.

(All the Figures, except Fig. 3*b*. magnified 25 diameters.)

FIG. 1*a*. *Beyrichiopsis fortis*, var. *glabra*, J. and K., left valve; 1*b*. dorsal edge of right valve; 1*c*. ventral edge. Staneshiel Burn.
,, 2. ,, ,, ,, left valve. Staneshiel Burn.
,, 3*a*. ,, ,, var. *granulata*, J. and K.; right valve; 3*b*. hind end view, magnified 30 diameters. Staneshiel Burn.
,, 4. *B. simplex*, J. and K., right valve. Warksburn.
,, 5. *B. fimbriata* (?), J. and K., left valve. Cultra, Ireland.
,, 6*a*. *Beyrichiella cristata*, J. and K., carapace showing left valve; 6*b*. dorsal view. Randerstone.
,, 7*a*. *Beyrichia cratigera*, G. S. B., carapace showing left valve; 7*b*. ventral view. Arnside.
,, 8. *B. fastigiata*, J. and K., thick-shelled carapace showing cast of left valve. Sunday-night Cleugh.
,, 9 and 10. ,, right valves (thin-shelled).
,, 11*a*. *B. Bradyana*, J. and K., carapace showing left valve; 11*b*. ventral view.
,, 12. *B. arcuata* (Bean), right valve. Stylton, Durham.
,, 13. ,, ,, cast of right valve. Carluke.
,, 14. ,, ,, left valve. Longton, Staffordshire.

II.—New Palæoniscidæ from the English Coal-measures.

By R. H. Traquair, M.D., F.R.S., F.G.S.

Elonichthys Aitkeni, sp. nov., Traquair.

LENGTH, 6 to 7 inches, shape fusiform. Cranial roof bones sculptured with undulating ridges passing at times into elongated tubercles. Mandible sculptured externally with slightly undulating longitudinal ridges, which run tolerably parallel with the upper and lower margins of the jaw; dentary margin finely tuberculated. Maxilla of the usual form, its dentary margin likewise finely tuberculated, the rest of the surface covered with undulating ridges. Scales of moderate size; those of the front of the flank are higher than broad; posteriorly they become more oblique and equilateral, while towards the dorsal and ventral margins they become rather lower than they are broad. Their ornament consists of *sharp strongly-marked ridges, nearly straight and parallel,* and only occasionally bifurcating or intercalated. On the scales of the *anterior part* of the flank these ridges run rather *diagonally* over the surface of the scale from above downwards and backwards, but over the *greater part of the body* they are *parallel with the upper and lower margins of the scale,* and seldom does any greater obliquity of the ridges in the anterior and lower part of the scale give any indication of the diagonal division of the pattern which is so common in striated scales in the family Palæoniscidæ. Posteriorly, a peculiar and highly-ornamental character is given to the squamation by the fact that the lowermost ridge, uniting or not with the one next above it, is of unusual breadth, and stands prominently out. On the V-shaped ridge-scales of the caudal body-prolongation, the ornament becomes speedily obsolete, and the small lozenge-shaped lateral scales are at most marked by only one or two slight longitudinal furrows.

The length of the pectoral fin is about two-thirds that of the head, its principal rays are unarticulated for about one-third of their length. The ventrals are badly preserved, but their position seems to be intermediate between the pectorals and the anal. The dorsal is situated opposite the interval between the ventrals and the anal; both dorsal and anal fins are pretty large, and of the usual triangular acuminate shape; their rays are *delicate and slender, distantly articulated,* ganoid and smooth, save that now and then a single longitudinal furrow is seen especially just before bifurcation sets in. The caudal is large and deeply cleft; the articulations of the rays of the lower lobe are a little closer than those of the dorsal; in the upper lobe the joints become so short as to look nearly square-shaped.

Remarks.—Though hitherto undescribed, this fine species is pretty well known to collectors in the West of England, and cannot be confounded with any other. I have named it after the late Mr. John Aitken, of Bacup, Lancashire, who lent me the beautiful specimen, of which a figure will shortly appear in my memoir on Carboniferous fishes in course of publication by the Palæontographical Society.

Geological Position and Localities.—Lower Coal-measures. Copy

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Coal Mine, Cliviger (collected by the late Mr. Aitken): Arley Mine, Burnley, Lancashire (coll. of Mr. J. Wilde, Ashton-under-Lyne): Dalemoor Rake Ironstone, Stanton, Derbyshire (British Museum and Museum of Practical Geology): Millstone Grit Shales, Danebridge (Mr. J. Ward). There is a specimen in the Museum of Practical Geology, labelled from Ladieswell Colliery, Staffordshire, but in Mr. Ward's opinion the specimen more probably came from the Lower Coal-measures of the Cheadle district.

Elonichthys microlepidotus, sp. nov., Traquair.

I have only seen two specimens of this interesting form, which have been kindly lent to me by Mr. Ward.

The length of the more perfect of the two is 3⅜ inches; but as it is broken off immediately behind the anal fin, we may justly estimate the original length of the fish at not less than five inches. The external markings of the head-bones are not well seen, except in the case of the lower jaw, which is ornamented by wavy longitudinal branching and anastomozing ridges. In this specimen the mouth is wide open, as is also the gill-cleft, owing to the drawing forward of the suspensorium; the opercular bones are rather narrow, and beneath them and the mandible the branchiostegal rays may be counted. The scales are *small* in proportion to the size of the fish, and their markings consist of only a *few strong ridges passing horizontally or with only a slight obliquity across the scale.* Only the base of the pectoral fin is seen, the other fins are large, and have the form and relative position characteristic of this genus. Their rays are very numerous, fine, and closely set; their joints longer than they are broad, and their surfaces show traces of fine longitudinal striation.

Remarks.—The relative smallness of the scales and their peculiar simple bold ornament distinguish this species from any other with which I am acquainted.

Geological Position and Locality.—Knowles Ironstone Shale, Longton, Staffordshire, in the collection of Mr. John Ward, F.G.S.

Rhadinichthys macrodon, sp. nov., Traquair.

The specimen upon which this species is founded measures five inches in length, but it is broken off just behind the commencement of the caudal fin, as indicated by the dorsal ridge scales; the length of the head is 1¼ inch, and the depth of the body nowhere exceeds one inch. Consequently, the general aspect is that of a fish of slender form, but the specimen cannot be relied on as showing the original shape, as the scales are broken up and confused, and the fin-rays almost entirely wanting. The head exhibits the typical palæoniscid structure,—the suspensorium being very oblique, the gape wide, and the usual arrangement of opercular and branchiostegal plates being shown; the bones are, however, seen almost exclusively from their internal surfaces. Both jaws are armed with stout, conical, incurved teeth of *unusually large* proportional *size*, those of the maxilla measuring $\frac{1}{12}$ to $\frac{1}{10}$ inch in length; the small external ones are not visible. The scales are of comparatively large size, those of the anterior part of the flank having their exposed areas covered with delicate ridges and furrows, which are nearly parallel with the upper and lower margins of the scale, though they tend to turn upwards anteriorly; the posterior margin is sharply and prominently denticulated. As we proceed backwards, the scales lose the sharpness of their ornament, and become nearly smooth towards the tail, though the caudal V scales remain prominently striated. The origin of the pectoral fin is present, though not well shown, and here the principal rays seem unarticulated. A few broken up ray-joints mark the position of the dorsal and anal fins, the former occurring 3 inches, the latter 3¾ inches behind the front of the head.

Remarks.—The condition of the specimen renders its generic determination a matter of great uncertainty, but I am inclined to place it in *Rhadinichthys* for the following reasons:—(1), the apparent elongation of the body, on which, however, little weight can be placed; (2), the resemblance of the scales, in shape and ornament, to those of the typical *R. ornatissimus*, Ag. sp.; (3), the appearance of the broken rays of the root of the pectoral fin. Specifically I designate it as new, as I am not acquainted with any other form in which teeth of such large proportional size occur with scales of similar conformation and markings.

Geological Position and Locality.—Knowles Ironstone Shale, Fenton, Staffordshire, in the collection of John Ward, Esq., F.G.S.

(*To be continued.*)

III.—On the Lobe-line of Certain Species of Lias Ammonites Described in the Monograph by the late Dr. Wright.

By S. S. Buckman, F.G.S.

WHILE recently turning over the plates of this Monograph, my attention was arrested by the lobe-line figured on plate 63, and on looking at the explanation of the plate given on the opposite page, I was much surprised to see that it was stated to be the "*Lobe-line of Harpoceras ovatum, magnified.*" On the same plate, just below (fig. 4) is a side view of the *Harp. ovatum* with its lobe-line in situ, and I suppose it to be this lobe-line that is magnified. But there must surely be some mistake here. Compare the lobe-line, fig. 7, with that on fig. 4, and notice the much greater width of the siphonal saddle in fig. 4 (than in fig. 7), where, on account of the curvature of the fossil, it would be really smaller. To say nothing of the obliquity of the inner portion of that on fig. 4, where is the first auxiliary lobe (nearly as large as the inferior lateral in fig. 7) to be found in fig. 4? I think it will be apparent that for some reason or other the two lobe-lines are different. But is the lobe-line, fig. 7, the correct lobe-line for such a species as the *Harp. ovatum* here figured? I must say No! Turning for a moment to Wright's description of the lobe-line of *Harp. ovatum*, page 446, we find it stated, "*The suture-line is of the radians type.*" This is true enough of the suture-line shown on fig. 4, but I think any one who has paid attention to the suture-lines of this class of Ammonites could not possibly say that fig. 7 was a lobe-line of "*the radians type.*"

The further description given is accurate as regards fig. 7, but it cannot be said to apply to fig. 4. In fact the suture-line fig. 7 belongs to that group of shells of which the specimen of *H. elegans* (figs. 1, 2, 3 on the same plate) is characteristic, and that by some means or other an oversight has occurred and the suture-line of this specimen (*Harp. elegans*) has been figured in mistake for the one of *H. ovatum*. That it is no fault of delineation I feel positive, because fig. 4 is characteristic of the group to which *Harp. ovatum* would belong, while fig. 7 is characteristic of the group to which *Harp. elegans* belongs. Compare for confirmation of this opinion the suture-line, fig. 7, with the suture-line given by D'Orbigny (Pal. franç. Terr. jurass. plate 62) to *Am. primordialis*—otherwise *Am. opalinus* (Reinecke),—a very near ally of *Am. elegans*, or compare it with the suture-line of a specimen of *Am. concavus*, Sow. These shells belong to a group having a practically identical suture-line not at all like that of *Harp. radians*. Now turn to plate 80, and at first sight the evidence appears against me. Here we have in fig. 3 a suture-line which I consider is of the *opalinus* type, called the suture-line of *Harp. aalense*, and in fig. 5 the suture-line of apparently the *radians* type called the suture-line of *Harp. opalinum*; but let us now look at his description of the suture-line of *Harp. aalense*, page 459, and *Harp. opalinum*, p. 464, and we see that the descriptions *do not in any way agree with the figures*. It is in figure 3, not 5, as stated, that we find the siphonal saddle divided into two unequal portions, and the auxiliary lobes large and two smaller auxiliaries, because there are no auxiliary lobes in fig. 5. The fact is Wright has correctly described the lobe-lines belonging to the two species, but has never noticed that they were wrongly numbered, whilst on page 446 (plate 63) he has described as *the suture-line* of *Harp. ovatum* a suture-line belonging to a different group of species altogether. I have proceeded no further at present, as I only happened to notice these suture-lines because they were necessary to me in my own work. But having noticed the errors mentioned, I have penned these remarks, not with the intention of detracting in the least from the excellence of Wright's monograph, but to call attention to the subject, so that it may not mislead others or be the unsound basis of argument should any discussion arise concerning the validity of suture-lines as a means of identification.

IV.—ON SOME NEW OR IMPERFECTLY KNOWN MADREPORARIA FROM THE INFERIOR OOLITE OF OXFORDSHIRE, GLOUCESTERSHIRE AND DORSETSHIRE.

By ROBERT F. TOMES, Esq.

(*Continued from* p. 398.)

ADELASTRÆA CONSOBRINA, Edw. and Haime, sp. (not *Synastræa consobrina*, d'Orb., Prodromus).

WE are informed by M. Ferry that d'Orbigny was supplied with the greater part of the Corals of his Bajocien by M. Eugene Beabeau, of Langres, who has stated of the present species that it was first named *Calamophyllia glomerata* by d'Orbigny, and afterwards by an error *Synastræa consobrina*, and further, that he at the same time described in his Prodromus another species under the same name. MM. Milne Edwards and Haime, it appears, were misled by this error, and referred the Coral sent by M. E. Beabeau, to the *Synastræa consobrina* of the Prodromus. This in brief is the statement of M. Ferry, and it is obvious that the *Synastræa consobrina* of the Prodromus, and the *Clausastræa consobrina* of MM. Milne Edwards and Haime are not the same, and that the latter is the Coral forwarded by M. E. Beabeau from Langres.

As *Confusastræa* had been proposed as a generic name as long ago as 1849 by M. d'Orbigny, and several species placed in it by him in 1850, and recognized by Milne Edwards and Haime, M. Ferry appears to have entertained no doubt about the generic relationship of the present species, and he therefore unhesitatingly places it in the genus *Confusastræa*. An allied species *C. ornata* occurs also at Langres, which differs only from *C. consobrina* in having larger calices. Of this M. Ferry gives a description, in which mention is made of some peculiarities which may here be noticed. The corallum, he informs us, is formed of a successive aggregation of corallites, with lateral and marginal buds, joined with one another by a rudimentary wall. He further observes that the corallites are often superposed, the young calices frequently implanted in the old ones, and that they start from a common base, formed sometimes of a single individual.

No description is given of *C. consobrina*, but it is said to resemble the last species, but with calices which are constantly of smaller diameter.

The specimens from the Cheltenham district correspond with great accuracy with the description given of *C. ornata* by M. Ferry, except that the calices are smaller, and their diameter agrees very well with that given of those of *Clausastræa consobrina* by MM. Milne Edwards and Haime, which is undoubtedly the same species as the *Confusastræa consobrina* of M. Ferry. Budding occurs laterally and in the depressions between the calices of these Cheltenham examples, and the growth of one calice within another (rejuvenescence) is not unfrequent in them. This Coral appears to be plentiful in the Lower Coral-bed in the Sheepscombe valley, near Painswick, and I have seen a specimen taken from the Oolite marl at Leckhampton Hill.

Of *Adelastræa tenuistriata* I may remark that although when unworn it is quite unlike an *Isastræa*, yet when the septa are worn down, it is difficult to distinguish from *Isastræa tenuistriata*. With the latter it has often been confounded. The marginal budding will, however, always identify it. Its relationship to the fissiparous genus *Cladophyllia*, suggested by Professor Duncan, is entirely unsupported by evidence.

ISASTRÆA TENUISTRIATA, Edw. and Haime.

Since the appearance of my former paper I have examined a number of specimens of this species from the Lower Coral-bed at Crickley Hill and Birdlip Hill, from the Lower Trigonia Grit at Juniper Hill near Painswick, and from other localities in the

Cheltenham district. I have also obtained it from the Upper Coral-bed in the Slad Valley near Stroud. It is now therefore obvious that it has a considerable vertical range in the Inferior Oolite. A specimen from Birdlip shows its method of gemmation very clearly. It takes place either on the exposed margin of the wall between the calices or a very little within the calice, as even when still very small it is impossible to say from which calice the young one proceeded.

ISASTRÆA DEPRESSA, Tomes.

Besides the localities already mentioned in my communication on Inferior Oolite Corals, I have now seen examples from the Lower Coral-bed at Birdlip, and at Juniper Hill in the Painswick valley. I have also a specimen which was given to me by the late Dr. Bowerbank, with the information that it had come from Dundry Hill. Another specimen from the same locality is in the Northampton Museum. There is also one in the Museum at Oxford, which was taken from the Inferior Oolite in the Hook Norton cutting of the Banbury and Cheltenham Railway. The presence of this species at the latter place might lead to the conclusion that the lower beds of the Inferior Oolite are not unrepresented there.

CHORISASTRÆA GREGARIA and C. OBTUSA.

I enter with some reluctance into a repetition of what I have already insisted on respecting some corals which I placed in the genus *Chorisastræa.* So far as the two English species, *C. gregaria* and *C. obtusa,* are concerned, everything depends upon their mode of increase. If it is by fissiparity, then are these species simply Thecosmilians, but if accomplished by means of gemmation, some other genus than *Thecosmilia* must be chosen for their reception. Now, Professor Duncan himself, speaking of these same corals (Quart. Journ. Geol. Soc. vol. xlii. p. 128), says, "An attempt was made to include the well-known species of *Thecosmilia,* which *at first increase by gemmation* and then by fissiparity" (*i.e.* to include them in *Chorisastræa*). The words have been given in italics by me. A few pages further on (p. 113), he refers to one of my own figures in proof of fissiparity in *Chorisastræa gregaria.* That figure represents the earliest period when increase takes place, just at the time when the corallum ceases to be simple and becomes compound. This, according to Professor Duncan's own words, should be the period for gemmation, instead of fissiparity. The two statements are of course inconsistent with each other. The real fact is, gemmation and nothing else takes place, and we have exactly the same process which is represented by the figures of *Chorisastræa corallina,* From., *C. neocomiensis,* From., and *C. dubia,* Becker. One of the figures of the latter species (from the Corallien of Nattheim) bears a strong resemblance to some of the more simple examples of *C. gregaria,* and answers to the descriptive words of MM. Milne Edwards and Haime which they applied to their *Thecosmilia gregaria.* They say that the corallites of that species differ from those of *Thecosmilia* by "remaining in general *grouped in fasciculi* to a considerable distance from the parent calice." This is precisely what takes place in the various speices of *Chorisastræa*, and had those celebrated palæontologists seen and examined young examples at various ages, I do not for a moment believe that they would have placed *C. gregaria* in the genus *Thecosmilia.*

Chorisastræa obtusa from the Great Oolite differs chiefly from the preceding in being smaller. But some of the dwarfed examples of *C. gregaria* very closely resemble it. However, *C. gregaria* may at all ages be known by the greater thickness of its septa outwardly, that is, near the mural region. This peculiarity is observable in individuals, the corallum of which is so young that it has only the thickness and size of a small coin. The specimen of *C. obtusa* figured by Prof. Duncan is not very characteristic, one of that height would commonly have four or five calices, or even more.[1] Such examples as the one figured are however common in the Fairford Coral-bed.

In support of *Chorisastræa* as a genus I may only remark that if not Thecosmilian, the species I have here mentioned must be placed either in *Chorisastræa* or *Latimæandra,* and it can hardly be said that they fall properly into the latter.

CHORISASTRÆA, sp.

Peduncular portions of a species of coral referable to this genus have been obtained from the beds under the Pisolite at Crickley Hill, and from a sandy bed overlying the Upper Lias sands at Dover's Hill near Chipping Campden. All the specimens examined have very numerous, thin, and uniform septa, and they are probably attributable to some undescribed species.

Genus PHYLLOGYRA, Tomes, Q. J. Geol. Soc. vol. xxxviii. p. 430.

Since the definition of this genus appeared, I have examined some young examples of *Phyllogyra Etheridgei* from the Trigonia Grit of Leckhampton Hill, which enable me to confirm the characters I have before assigned to the genus. The smallest of these is not more than an inch in diameter. It has a flattened lenticular form, with a central large calice and a thin lobular outer margin, in the lobes of which gemmation is actively taking place, precisely as it does in the margins of small examples of *Chorisastræa gregaria.* Between the marginal lobes are subcristiform ridges, just as in that species, and such as I have figured in plate xviii. illustrating the paper above quoted. It is obviously by gemmation, and not by fissiparity, that increase in this genus takes place, as the central calice is not in any way interfered with by the simultaneous growth of a circle of new calices in the distal ends of the surrounding septal costæ. Gemmation as it takes place in *Phyllogyra* is precisely as in *Latimæandra*, and as it has been figured by Prof. Duncan himself in his Supplement to the British Fossil Corals, plate v. fig. 7 of part ii.

It is by no means improbable that *Phyllogyra Etheridgei* and *Chorisastræa gregaria* may prove to be forms which differ only from each other; the one by having a depressed and expanded growth, and the other by having a subdendroid form. For the present I leave them where they are, but must enter my earnest protest against there being any near affinity with *Symphyllia* in the Oolitic form now under consideration.

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[1] Since writing the above the specimen figured by Prof. Duncan as *Thecosmilia obtusa* has come into my hands. Of it I shall have more to say on a future occasion.

PHYLLOGYRA SINUOSA, Tomes.

I have lately met with several examples of this species in the Lower Trigonia Grit near Cheltenham, but in no instance in the Coral-bed at Crickley. It has not, indeed, been observed in the Lower Coral-bed at any locality, though it most frequently occurs in the Oolite marl, or third Coral layer.

PLATASTRÆA ENDOTHECATA, sp. nov. (Plate X.[1] Figs. 1, 2, 3, 4.)

Clausastræa Conybeari, Tomes, Proc. Geol. Assoc. vol. vi. no. 4.

The present species, the occurrence of which I have already recorded, under the name of *Clausastræa Conybeari*, must, with the allied species from the Great Oolite of Bath, be referred to the new genus *Platastræa*. Specimens from the Inferior Oolite of Hook Norton are for the most part fairly preserved, and sometimes when broken through, show the structure of the septa and the dissepimental tissues very clearly.

The corallum is rudely lenticular, and not very large. The upper surface is moderately convex, sometimes almost flat, and never much elevated, and the outer margin is rather thin, but rounded rather than angular. The under surface is much more prominent than the upper surface, in some specimens almost subpeduncular, with a central point indicating a former attachment. The common or basal wall is rudimentary, and has intermittent and narrow rings of epitheca. The radiating mural costæ are thin, and the spaces between them are wide and filled with dissepiments. The calices have a more or less quadrangular or rounded outline, and are shallow. The septa are all of them continuous with those of other calices, but they often form an angle where they meet and unite between the calices. They are very stout over the mural region, but speedily become thinner as they approach the visceral cavity. The margins of all of them are denticulated, the teeth consisting of rather large, regular, and rounded tubercles, the greater diameter of which is across the septum. There are four cycles of septa in six systems. In some systems the fourth cycle is incomplete, while in others there are a few very rudimentary septa of the fifth cycle.[2] The primary septa extend to the fossula and meet, the secondary ones are very little shorter than the primary ones, and those of the tertiary cycle are a little more than half the length of those of the primary cycle, while those of the fourth cycle are quite short.

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[1] This Plate was published in the September No. with the first part of this paper.

[2] I must differ wholly from Prof. Duncan when he says that there are never two rudimentary cycles in the same calice. There are not ever, to the best of my knowledge, two rudimentary cycles in the same system, but there may be, and often are, in the irregularly developed calices of Jurassic Madeporaria, rudimentary septa of quite different ages in different systems. The third cycle may be rudimentary in one and complete in another, in which a fourth may have even commenced its growth. Such irregularities are frequent after recent rejuvenescence, one side of the calice having perhaps the full complement of septa, while the other may have only the earlier developed cycles.

The dissepiments are very numerous; stout, arched, and they completely fill up the loculi. They continue so high up in them that they are seen almost close beneath the denticulations of the septa. The diameter of a large corallum is from three to four inches, and the height about one inch. The diameter of the calices is half an inch. Increase takes place by gemmation in the interval between the calices.

Although allied to *Platastræa Conybeari* from the Great Oolite, the present species may be readily distinguished from it by its much smaller size and regularly lenticular form. Again, the septa of *P. Conybeari* meeting in the centre of the visceral cavity, are much thickened quite low down in it, and these form a mass which, when those parts of the septa which are above it have been worn down, comes in view, and has so much the appearance of a columella as to have led MM. Milne Edwards and Haime to place the species in the genus *Plerastræa.* Nothing of the kind is observable in *Platastræa endothecata.*

I take the present opportunity of making a few remarks on *Platastræa Conybeari.* It is not rare at Coombe Down, from which place the type-specimens were obtained. It is sometimes of great size, and although, generally speaking, of a globose form, is often extremely irregular in its outline, and the calices on some parts have a corresponding irregularity in shape. When these irregular calices are worn down, they present precisely the appearance of those shown in the figure of *Clausastræa Pratti* figured in the History of British Fossil Corals. But the more regular calices of *Isastræa Conybeari,* figured on the same plate, would never by any condition of fossilization or any amount of wear resemble those of the then supposed *Clausastræa.* But indeed no one except Prof. Duncan has suggested such a possibility.

Of the type-specimen of *Clausastræa Pratti* (afterwards *Plerastræa Pratti*) the original describers observe that it is so ill preserved that they could not give a complete description of the species from it. Notwithstanding this, no doubt seems to have crossed Prof. Duncan's mind as to its fitness to furnish a satisfactory description, and he has accordingly entered quite recently into its details.[1] I also have lately examined the type-specimen, and can confirm what has been said of its unfavourable condition by MM. Milne Edwards and Haime. It is a young example and bears a very close resemblance to many of the specimens from Coombe Down. The supposed papillose columella observed in some of the calices is nothing more than the blending of the septa in the centre of the calice, the denticulations of which, resembling in shape those I have figured on the plate accompanying this communication,[2] are yet traceable in that part of the calice which has been subjected to the least wear—that is to say, in the centre. All other parts of the septa have been worn down quite smooth.

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[1] Quart. Journ. Geol. Soc. vol. xlii. p. 138.

[2] Plate X. Figure 3.

In the description of the so-called *Clausastræa Pratti* by the original describers it is stated that the calices are not separated by a distinct wall; all the Coombe Down specimens I have seen, whatever their condition, accord in this particular with the type. They are equally destitute of surrounding wall, whether they have the irregular form of those of *Clausastræa Pratti*, or the more regularly defined ones of *Isastræa Conybeari.* Turning to the description of the genus *Plerastræa* by MM. Milne Edwards and Haime, M. de Fromentel, and Prof. Duncan, I observe that special mention is made of the presence of walls surrounding the calices. I must therefore still contend that *Platastræa* is generically distinct from *Plerastræa,* which has distinct walls bounding the calices.

Further, I must continue to assert the identity of the two species *Isastræa Conybeari* and *Plerastræa Pratti,* the latter being nothing more than a small specimen having an irregular growth, and a corresponding irregularity in the development of the calices. And I must repeat my assertion that the same specimen of this variable species will on different parts present the appearances represented by the figures given by MM. Milne Edwards and Haime of *Isastræa Conybeari* and *Plerastræa Pratti.*

Genus LEPTOPHYLLIA, Reuss.

The conclusions of M. Pratz respecting the structure of the corallum of the genus *Leptophyllia* were based on the examination of specimens of the very species on which Reuss established the genus. They were obtained from the Cretaceous formation at Gosau, and he observes that proof is yet wanting that these Cretaceous and other subsequently described species from the Oolites are generically identical. At present my knowledge of the Oolitic Leptophylliæ is confined to the examination of a few examples of a small species from the Inferior Oolite. In these I observe the same form of pseudo-synapticulæ as in the Gosau Leptophylliæ, and in the genus *Thamnastræa*; they therefore, very probably, appertain to the genus *Leptophyllia.* One of these small and malformed Oolitic *Leptophylliæ,* from the Inferior Oolite of Dorsetshire, has been figured and described by Prof. Duncan under the name of *Podoseris constricta.*

LEPTOPHYLLIA FLOURESTI, E. de From.,

Pal. Franc. Terr. Jurass. Corall. p. 93, pl. 27, figs. 1–4, Oct. 1866.

One example of this species has been taken from the Oolitic Marl at Leckhampton by me, and I have another given to me by my friend Mr. W. C. Lucy, which he obtained from a bed of angular oolitic gravel near Painswick. The Painswick specimen is misshapen, and has a curiously close resemblance to figure 3 of the plate above quoted.

Genus THECOSERIS, E. de From.

Palæoseris, Duncan.

Since the publication of my paper in which the description of *Thecoseris polymorpha* appears, I have examined a specimen of that species which had been split through vertically, showing the sides of the septa with great distinctness. The so-called pseudo-synapticulæ are very clearly shown, and appear as ledges passing continuously across the septa in lines parallel to the septal edge. There is not the slightest indication of perforations between these ledges, but there are well-defined dissepiments low down in the corallum. The genus *Thecoseris* differs wholly from *Leptophyllia* in having imperforate septa and an investing wall with a well-developed epitheca, giving to the calice a clearly-defined and prominent margin. These differences sufficiently characterize *Thecoseris*, and at the same time distinguish it from *Leptophyllia*. They also afford good reasons for declining to accept the position of a subgenus assigned to them by Prof. Duncan.

When I stated my belief that *Palæoseris* would be found to be identical with *Thecoseris*, I did not know that Zittel had already referred it to that genus. That *Thecoseris* should be a Cretaceous as well as a Jurassic and Tertiary genus, might be anticipated, and accordingly a species has been described in Stoliczka's work on the Cretaceous Corals of Southern India.

THAMNASTRÆA EXPANSA, sp. nov.

I have met with a *Thamnastræa* at Birdlip Hill, Gloucester, in a Coral-bed which is an extension of the one at Crickley Hill, having characters which do not accord with those of any species I am acquainted with, and I therefore describe it under the above name.

The corallum is broad and saucer-shaped, very thin, and has a slight peduncle. The margin is extremely thin and wavy. The epitheca is well developed and concentrically wrinkled. The calicular surface is very slightly concave, and a little deeper in the centre. The calices are extremely small, circular, and regularly distributed, and there is very little disposition in the septal costæ towards the parallel arrangement observable in so many species of *Thamnastræa*. About twenty-four septa enter into and form the calice, twelve of which unite in pairs at the fossula. The others are short. The fossula is small, round, but not very deep. All the septa and septal costæ are very delicately papillated.

Diameter of the corallum, 3 inches; its thickness, ½ inch.

Distance from centre to centre of the calices, 1 line.

THAMNASTRÆA HETEROMORPHA, sp. nov.

The corallum has a very complicated outline, somewhat resembling that of *Dimorphophyllia*, but much more irregular and less compact. Proceeding from a common centre, it expands upwards and outwards into a considerable number of leaf-like and lobular parts, which are in clusters, and have openings through and between them. The calicular surfaces are horizontal and divided; they are numerous, and having their margin turned up, present extremely irregular shallow cavities. All the under parts of these leaf-like lobes have a well-developed and rugose epitheca.

The calices are for the most part in rows corresponding with the outer margin of the lobes. They are shallow, but have a well-defined and rather large fossula. There are from sixteen to eighteen septa, of which twelve are of equal length and form the fossula. The rows of calices are connected by septal costæ, which are nearly parallel, and run towards the outer margin of the lobe. Very few anastomoze, but all, as well as the septa, are regularly papillated. In the fossula is a well-defined columella consisting of about twelve regular styliform papillæ.

Height of the corallum, about 1½ inch, and its greatest diameter about 3½ inches. The calices are distant from each other about one line.

I have met with a few specimens in the Oolite Marl at Leckhampton Hill, but not at any other place.

DIMORPHARÆA EXPANSA, sp. nov.

I possess four specimens of *Dimorpharæa*, from the Inferior Oolite of East Coker, they are very distinct from *Dimorpharæa Oolitica*, which I describe as follows:—

The corallum is very broad and thin, and the upper and under surface have about the same degree of convexity. The largest specimen has a diameter of four inches, while in thickness it does not exceed half an inch. The outer margin of all the specimens is quite thin. In all of them the mural costæ are visible on the under surface, only a very small quantity of epitheca being present. This is distributed in patches. These costæ are straight, uniform in size, and they radiate from a centre.

The middle or parent calice has very little prominence, and is only a little larger than the surrounding ones, which are ranged around it in circles, so irregularly that they look almost scattered. There are, however, three circles of secondary calices, and outside the external one the septal costæ are prolonged to a length exceeding the distance between the circles. From this it might seem that three is the full complement of circles, unless the distance between the circles increases rapidly as the corallum enlarges.

From twelve to sixteen septa enter into and form the calices. In the most regularly formed there are twelve, of nearly equal length and thickness, extending to the fossula, but they do not enter into it. They have perforations, which are not numerous, but are large and distinct. The septal costæ are of equal thickness with the septa, as well as equally thick throughout; they are straight or wavy, rarely curved, and have a radiate arrangement. The breadth of the intervals between them rather exceeds their own thickness.

At present I have been unable to examine specimens having the septal edge complete.

COMOSERIS VERMICULARIS.

A specimen of *Comoseris* which I took from the friable Pisolite at Crickley Hill is obviously specifically identical with the specimen I have already referred to *C. vermicularis* obtained from the overlying Coral-bed at that place.[1] It is a young and worn example, but is very instructive as to the habit of growth of the species. A short peduncular foot is surmounted by a tuber-shaped top, which is composed of overlapping leaflets, and where the lateral margins of these meet on the upper surface, they curl up and form ridges having precisely the same sinuosity as the margins of the leaflets. It is only, however, at the outside of the corallum that the outline of the leaflets can be satisfactorily traced. On the whole of the central part they are too much fused together to be followed excepting as sinuous ridges, which being worn down, reveal the hidden wall within.

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[1] Quart. Journ. Geol. Soc. vol. xxxviii. p. 448.

In 1884, when Prof. Duncan published his Revision of Families and Genera, he did not admit that there was any wall in the collines of *Comoseris*; but in his recently published paper in the Journal of the Geological Society he acknowledges that there is a false wall. This is a step in the right direction. With patience and further research a true mural structure may yet be arrived at.

This is the only species I have met with which is common to the Pisolite and the overlying Coral-bed; but as the specimen from the former deposit was found in the friable or disintegrated part, it may have fallen from above and have been embedded.

PHYLLOSERIS INCRUSTATA, Mich. sp.

Alveopora incrustata, Mich. Icon. Zooph. p. 111, pl. 25, fig. 8, 1840–47.
Microsolina incrustata, M. Edwards, Hist. Nat. Corall., tom. iii. p. 201, 1860.
Phylloseris, sp. Tomes, Q. J. G. S. vol. xxxviii. p. 448, 1882.

The species of *Phylloseris* which I indicated at page 448 of my paper on Inferior Oolite Corals is obviously identical with the *Alveopora incrustata* of Michelin. Although described by that author as a dendroid species, and having the "rameaux" partially covered by an irregular "croute," it is obvious by the figure that it has more of a digitate than a dendroid growth. That it is a second species of *Phylloseris*, differing chiefly from *P. rugosa* in the form of the corallites and the size of the calices, I have no doubt. The epitheca extends upward by degrees and obliterates the calices, just as it does in *Phylloseris rugosa*.

LATIMÆANDRARIA CONCENTRICA, Tomes.

Oroseris concentrica, Tomes, Quart. Journ. Geol. Soc. vol. xxxviii. p. 441.

In a paper on the Madreporaria of the Coral Rag (Quart. Journ. Geol. Soc. vol. xxxix.) I suggested that a species of *Oroseris* which I had before described as *Oroseris concentrica*, probably appertained to another genus. I now place it in *Latimæandraria*, and I do so for the following reasons. As clearly pointed out by me, *Oroseris* may be recognized by its mode of gemmaparous increase, which is calicular or marginal, while in *Latimæandraria*, *Thamnastræa*, and some other genera, it is intercostal. As it is also intercostal in the present species, I now place it in the former of these genera.

In conclusion I wish to render my very sincere thanks to Mr. Hudleston, Mr. Buckman, and Mr. Jas. Windoes for their liberal assistance in the use of specimens from their several collections.

V.—ON A DEEP BORING IN THE NEW RED MARLS (KEUPER MARLS) NEAR BIRMINGHAM.[1]

By W. JEROME HARRISON, F.G.S.

THE Triassic strata which form the country surrounding Birmingham consist of the usual divisions of sandstone and marl; the sandstones predominating below, the marls above. In the immediate neighbourhood of the town, the sandy beds are divided from the marly or clayey strata by a dislocation or line of fault which runs from north-east to south-west, taking a line from Erdington to Rubery, and traceable altogether for a distance of about twenty miles. The fault runs through the town of Birmingham nearly parallel to the River Rea, and from a quarter to half a mile west of the present bed of the river. The Lower Keuper sandstone, which forms a surface band one to two miles in width on the west of this fault, is a porous stratum about 200 feet in thickness. It is underlain by the Bunter Pebble Beds, 300 to 400 feet in thickness, which crop out further to the west, and which contain an inexhaustible supply of water. From three deep wells in the suburbs of Birmingham—two on the north at Perry and Witton, and one on the south near Selly Oak—the Corporation Waterworks obtain daily a supply of over eight million gallons of water, most of which comes from the Pebble Beds, which occupy the lower portion of each well or bore-hole. The water is of good quality, showing from nine to fifteen degrees of hardness.

On the east of the line of fault a very different state of things prevails. The rocks on this side have been dropped vertically some six or seven hundred feet. Here the surface is composed of the Keuper Red Marls, which form a broad band ten or twelve miles in width, extending from Birmingham to Shustoke. The water-supply of this tract—which has a considerable extension to north and south from Tamworth to Warwick and Redditch—is wholly derived from superficial sources, such wells as exist drawing their water from the post-glacial sands and gravels which lie here and there in hummocks on the Red Marls.

As the population on this agricultural plain of Warwickshire is comparatively small and scattered, and as there are no manufacturing towns in the district, it is, perhaps, not surprising that until quite recently no attempts have been made to reach the buried waters which probably exist in the Bunter and Keuper Sandstones that underlie the Red Marls on the east of the line of fault. The chief obstacles to such an undertaking are the unknown—certainly considerable—thickness of the Red Marls; and the fact that no one likes to be the first to experiment in a matter in which—while there is certainly a possibility of failure—any good result obtained would be quite as much for the benefit of one's neighbours as for one's self. It would seem that such borings might be executed by Government, or by the County Boards which it is proposed to establish, the cost being defrayed by a small tax levied on the landowners of the district.

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[1] Read before Section C. (Geology), British Association, Birmingham, September 3rd, 1886.

The work of the Geological Survey has given us some information as to the probable thickness of the Red Marls. Prof. Jukes, writing of South Staffordshire,[1] says:—"The total thickness of this sub-formation cannot be much less than 600 feet;" and Mr. Howell, speaking of this very district,[2] states that "south of Birmingham the Keuper Marls attain a thickness of nearly 600 feet," and again adds "in this district, the Red Marl attains a maximum thickness of about 600 feet." However, he gives a section of a boring on the Lindley Hall Estate (four miles north of Nuneaton), about which, although a depth of 660 feet was attained, he says, "it does not seem certain that they got through the Red Marl series; some of the lower beds, however, may belong to the Lower Keuper Sandstone." In a deep boring for water, at Rugby, after passing through 400 feet of Lias and seventy feet of Rhætic Beds, the New Red Marls were pierced, and found to be 670 feet in thickness; at a depth of 1140 feet the Keuper Sandstone was reached, and a rush of water flooded the bore-hole; unfortunately this water was so impregnated with salt and with gypsum as to be unfit for domestic purposes.

About eight or ten years ago the Birmingham Corporation put down a bore-hole in Small Heath Park (a southern suburb of Birmingham), in search of water for certain baths and wash-houses which it was proposed to build there. A depth of 440 feet was attained, entirely in the Keuper Red Marls, before the boring was abandoned. I have seen numerous specimens of fibrous gypsum obtained from varying depths in this bore-hole.

Early in the present year Messrs. Bates, of the King's Heath Brewery, three miles south of Birmingham, resolved to make a deep boring for water through the Red Marls on which their buildings stand, at a distance two miles to the east (down-throw side) of the line of fault already described. They entrusted the work to Messrs. Le Grand and Sutcliffe, of 100, Bunhill Row, London, who have successfully carried out similar undertakings in many parts of the country. The work has been rapidly carried forward, and the latest statement of results is as follows:—

Contractor's Notes.	Depth in Feet.	Geological Notes.	Feet.
Dug well...	32	Post-glacial Sands	36
Red Sand	4		
Red Marl and Pebbles	8	Boulder Clay	20
Rough Ballast	12		
Red Marl	158	Keuper Marls	611
Red Marl and Gypsum	131		
Marl, Shale, and Gypsum ...	309		
Marl and Shale	3½		
Red Stone and Shale	9½		
Total depth reached ...	667		667

There is no thick bed of gypsum, but this mineral occurs persistently in streaks and fibrous deposits throughout the greater part of the strata. Many of the cores of marl brought up are remarkably hard, affording a great contrast to the ordinarily soft and crumbling nature of the strata as we usually see them in a weathered condition in brick-pits, etc.

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[1] Warwickshire Coalfield, Survey Memoir, 1859, pp. 41–44.

[2] South Staffordshire Coalfield, Survey Memoir, 1859, p. 4.

It is possible that the "red stone and shale"—a hard sandy marl —which forms the bottom bed now reached, marks the incoming of tho Lower Keuper Sandstone. Similar strata were found at the bottom of the Lindley Hall boring. Certainly the depth already reached—667 feet—is the point at which our previous knowledge would lead us to expect the change to occur. For although the first 56 feet is occupied by surface-deposits, leaving 611 feet for the Red Marls, yet it must be remembered that we are only two miles east of the fault, and that the upper portion of the Marls—to what extent we cannot precisely tell—must have been removed by denudation.

Just as the boring has reached this most interesting point, an unfortunate accident has temporarily delayed its progress. A tool has broken in the very bottom of the boring, and the removal of the broken piece is a difficult operation. But doubtless this obstacle will quickly be overcome. As to the quality of the water to be obtained from the Keuper Sandstones, the promoters of the boring doubtless hope that it will be similar to that at Burton, where the presence of a moderate amount of gypsum in the water from deep wells sunk through the Red Marls is found to be of great value in brewing operations.

The action of a fault when it brings a thick bed of impervious material like clay or marl side by side with a porous sandy stratum— the sandy beds dipping towards the line of fault—is strikingly shown both at Birmingham and Stourbridge. In Birmingham there is any quantity of water to be had from the Sandstones and Pebble Beds right up to the line of fault. The artesian well, about 200 feet deep, in Digbeth, must be within a few yards of the fault-line, and the water obtained is used in the manufacture of mineral waters, and is so highly prized that it may frequently be seen conveyed in a large barrel on wheels to various establishments in the town.

At Stourbridge exactly the same thing happens. A north and south fault brings Permian Marls on a level with the Bunter Pebble Beds and Keuper Sandstones, the latter dipping towards the Marls. The water is banked up by the Marls and yields an unlimited supply to the wells of the Stourbridge Water Company, which lie just on the right (west) side of the line of fault.

The railway company occupies the land on the marly side of the fault, and in years gone by they sank well after well in the marls in vain search for water, and the officials were much chagrined and surprised at its absence, seeing that any quantity of the precious fluid was being pumped up within a few yards of their land!

VI.—ON PALÆOZOIC PHYLLOPODA.

By PROF. T. RUPERT JONES, F.R.S., F.G.S.[1]

SINCE the publication of the Third Report on Palæozoic Phyllopoda (Brit. Assoc. Report for 1885), we have examined many additional specimens in the Museums of the Edinburgh and Glasgow Universities, and in the Braidwood Museum belonging to Dr. J. R. S. Hunter, of Braidwood, near Glasgow. Mr. James Thomson, F.G.S., has given us a quantity of nodules. containing remains of *Ceratiocaris*, from the Lesmahago district; and other friends have lent us several interesting specimens.

We have also again critically examined the fossils enumerated under *Ceratiocaris*, in the Third Report, and, having had numerous finished drawings carefully made for illustration of a forthcoming monograph for the Palæontographical Society, we have been able to compare them more perfectly and with more precise results.

Thus we find that—

1. *Ceratiocaris leptodactylus* (M'Coy), see Third Rep. pp. 11–14, as known by its caudal appendages (Cambr. Mus. *a*/923, *a*/924, and a few others), is distinct from *C. Murchisoni*, M'Coy, both as to size and proportions. We have traced two rows of pits (bases of prickles) on *a*/924, as exposed. Some similar caudal appendages, M.P.G. $\frac{11}{14}$, occur in the Lower Wenlock rock of Helm Knot, Dent, Yorkshire.

2. *C. Murchisoni* (Agass.), founded on some specimens figured in Sil. Syst. and Siluria, but unfortunately lost (Third Rep. p. 11, etc.), is represented by several analogous fossils, such as Oxford Mus. B and C; Ludlow Mus. C; M.P.G. $\frac{23}{33}$ and $\frac{23}{36}$. We find only one row of pits on the styles, as exposed. We have been unable to determine its carapace; but a fragment lying in the same slab with $\frac{23}{36}$ may belong to it. The carapaces formerly assigned to *C. leptodactylus* and *C. Murchisoni* (Third Rep. pp. 12, 15) are now regarded as belonging to distinct species.

3. The caudal appendages of *C. Murchisoni* have a slight curvature; there are others much like them, but straight, and associated with a large ultimate segment, much broader than that in M.P.G. $\frac{23}{36}$. (For instance, Oxford Mus. F; M.P.G. X $\frac{1}{2}$; Ludlow Mus. T.) One of these (X $\frac{1}{2}$) has been labelled *C. gigas* by Mr. Salter; and therefore we adopt that name.

4. The specimens from the Wenlock beds of Dudley and Kirkby Lonsdale, described and figured in the GEOL. MAG. 1866, p. 204, Pl. X. Figs. 8 and 9, as belonging to *C. Murchisoni* (Third Rep. p. 12), are too thick and strong for that species, and the Dudley example (Fig. 8) has different proportions. We propose to distinguish them as *C. valida.*

5. Some abdominal segments (Oxford Mus. E; Ludlow Mus. L; B.M. 39403; M.P.G. $\frac{23}{35}$ and $\frac{23}{36}$; Third Rep. p. 20, etc.), narrow in

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[1] Being the substance of the Fourth Report of a Committee consisting of Messrs. R. Etheridge, F.R.S., H. Woodward, LL.D., F.R.S., and Prof. T. Rupert Jones, F.R.S. (*Secretary*), on the Fossil Phyllopoda of the Palæozoic Rocks, read before Section C. British Association, Birmingham, Sept. 8, 1886.

proportion to those in other specimens marked $\frac{88}{36}$, and referred to *C. Murchisoni*, and very much narrower and smaller than in *C. gigas*, we separate as a new species, to be called *C. attenuata*. They have straight styles and stylets, very much shorter than in either of the foregoing.

6. Two small specimens of crushed telsons (one in Mr. Cocking's collection, and the other M.P.G. X $\frac{1}{28}$, both from the Ludlow series), probably smaller than *C. Murchisoni*, have a fluted or channelled sculpture on their upper part, instead of either wrinkles or leaf-pattern; hence they may be regarded as belonging to a distinct form, for which the name *canaliculata* will be convenient.

7. One fine large carapace (M.P.G. X $\frac{1}{6}$) and others smaller and less definite in some respects (M.P.G. X $\frac{1}{7}$; X $\frac{1}{8}$; X $\frac{1}{6}$: Ludlow Mus. A; Oxford Mus. K and J), and associated with segments and appendages, we regard as distinctive of a new species, though hitherto referred to *C. leptodactylus* (Third Rep. pp. 12, 15). The test appears to have been of an unusually solid consistency.

These carapaces in some instances have been much modified by pressure, but we trace a close similarity throughout the series, allowing for probable differences of age. The shape approximates to that of Dr. James Hall's species *C. acuminata* and F. Schmidt's *C. Noetlingi* (Third Rep. p. 30). There are marked differences, however, and we intend to designate this form *C. Halliana*, in honour of our old friend, who began working at these Phyllocarida as early as 1852.

A perfect specimen of *C. acuminata*, Hall, has been lately described and figured by Dr. Julius Pohlman in the Bulletin of the Buffalo Society of Natural Sciences, vol. v. No. 1, 1886, pp. 28, 29. pl. 3, fig. 2. Its caudal appendages are much like those of *C. papilio* and *C. stygia*, the style being relatively short, and the stylets broad and blade-like. The appendages in M.P.G. X $\frac{1}{7}$, X $\frac{1}{6}$, and Ludlow Mus. A are different from these, being thinner, tapering slowly, and pitted in at least one row, as exposed.

8. *C. Pardoeana*, La Touche. Two carapaces with segments and parts of appendages from Ludlow (Ludlow Mus. B and D; Third Rep. p. 12) differ from any other form. One of them (B), with a wrong caudal appendage attached to it, in the Ludlow Museum, has been labelled '*C. Pardoensis*,' and as such is referred to in J. D. La Touche's Guidebook to the Geology of Shropshire. We retain this name (altering the termination, as it refers to a person, and not a place) for the two carapaces here referred to. One of them (B) is of special interest as having its *rostrum* still in place.

9. The fine large specimen of *C. ludensis*, H. W. (Third Report, p. 16), has been again carefully studied, and we find reason to believe that the caudal appendage which appears longest in the fossil was not really the longest, or the true telson, but was one of the 'laterals' or stylets. Hence the whole animal was probably much longer than our former estimate made it.

10. *C. robusta*, Salter (Third Report, p. 24), being based merely on some small caudal appendages (Cambridge Museum *a*/925 and

a/926) without carapaces, is troublesome and unsatisfactory to deal with. We find some equivalent styles and broad blade-like stylets, like long scalene triangles, in *C. papilio*, *stygia*, *acuminata*, etc.; but none of these seem small enough for the several little sets of trifid appendages, more or less perfect, which we have met with. *C. robusta* takes in some of these; but Oxford Mus. T is relatively broad, and might be termed *lata*; B.M. 58878, from Muirkirk, has very narrow members (*angusta*); and one set in the Owens College is so neat, symmetrical, and small that it might be called *minuta*.

11. The specimens Ludlow Mus. S. and M.P.G. X$\frac{1}{17}^2$ have each a long style and a strong stylet attached to a broken ultimate segment, and were regarded as var. *longa* in the Third Report, p. 25. Although not showing the lattice-pattern so often seen on the segments of *C. papilio* and *C. stygia*, they may well belong to one of those species, and the ornament may have flaked off from the ultimate segment. The study of *C. papilio* and *stygia* (Third Report, pp. 16–20) we have not yet exhausted by any means. We know, however, that the abdominal segments were delicately sculptured with leaf-like or lattice-pattern ornament, the points of the triangles pointing upwards, or rather backwards, towards the carapace, and one limb of the triangle, where free, running downwards and outwards in the other direction. These oblique lines are often visible when the triangles have disappeared from wear or decomposition. Among many others the segments M.P.G. X $\frac{1}{17}^1$; B.M. 41900; Oxford Mus. A and H exhibit fine examples of this leaf-like ornament; and it is visible in several more complete individuals in those collections. In the Braidwood and Glasgow Museums numerous specimens show it well. See also Third Report, p. 31.

12. A small and very delicate specimen, B.M. 59648, has a thin subovate carapace, with excessively fine parallel longitudinal striæ, and shows 14 or 15 segments, some within and five outside the carapace, ending with a neat trifid set of appendages. This differs from any other form we know; and probably some small loose bodies, of numerous segments, occurring in the Lesmahago shales (Third Report, p. 20) may be of the same species. Its looseness of structure would suggest the name *laxa*.

13. Of *C. Salteriana*, noticed as a new species in the Third Report, p. 23, we have not yet seen any additional specimens.

14. The specimens which we referred to in the Third Report pp. 23 and 24, as *C. cassia*, Salter, are separable into two forms. *C. cassia* proper is recognized on an interesting slab, of which one counterpart is in the Ludlow Museum (E and F) and the other in the Museum of Practical Geology at Jermyn Street, London (X$\frac{1}{1}$). The other, somewhat similar, but larger and otherwise different, specimens are not unlike in the characters of the carapace, but they have more abdominal segments exposed and proportionally longer caudal appendages—M.P.G. X$\frac{1}{28}$; B.M. 39400; Ludlow Mus. K; Oxford Museum L and Q. These might be conveniently named *C. cassioides*.

In all the specimens of both kinds the carapace has been apparently thin and tough, so as to allow of their being crumpled very much. This condition and the presence of harder parts of their internal organs beneath give rise to various tubercular irregularities of the surface, in some cases simulating ocular tubercles. There are, however, no real eye-spots. There may have been irregularities of the surface, due to the attachment of the muscles of the jaws within the body.

15. An ovate carapace, represented by a mere film, and five abdominal segments, with a neat trifid tail, all flattened but very distinct, have no close ally among the known forms. The segments are delicately striate, with oblique lines on each side, suggesting the name *compta*, which we propose for this specimen—Ludlow Museum E.

16. To *C. inornata*, M'Coy (Third Report, pp. 20, 21), we have nothing to add, except that some large specimens (so named, Cambridge Mus. *b*/35) have a greater proportional depth (height) at the ventral border than smaller individuals, and yet have the same general outline and posterior slope, as well as the longitudinal lineate ornament. (The presence of this sculpturing is not in accordance with the trivial name.) These large specimens may belong to *C. stygia*.

In the Cambridge Museum is a specimen (*b*/36) of two abdominal segments, with a style and a stylet in good preservation, being convex and not injured by pressure. The penultimate segment is smooth, but shows faint traces of oblique lines; the ultimate is quite smooth and cylindrical; the telson (style) is attached by an apparently rounded joint; and the two uropods much resemble some of those referred to *C. robusta*. This specimen is from Benson Knot, and is labelled *C. inornata*; but the evidence of its specific relationship is supported only by its having been found in the same rock, and by its size suiting the large form of *C. inornata*? (*b*/35). It belongs possibly to *C. stygia*.

17. From the list for *C. inornata*, given in the Third Report, we have to remove one of the specimens found at Benson Knot, and marked '44342' in the British Museum, being decidedly different in outline (more ovate), though similarly marked with longitudinal striæ. It might well be named *C. Ruthveniana*, in memory of the old geological collector who laboured for very many years in the Kendal district for Professor Sedgwick and others.

18. *C. oretonensis* and *truncata*, H.W. (Third Report, pp. 21, 22), though near to *C. inornata* in shape, hold their distinct places as species.

19. Of *C. solenoides* and *C. gobiiformis* (Third Report, p. 22) there is nothing new to be stated.

20. As intimated in the Third Report, pp. 27, 28, the presence of the ocular tubercle has an important signification, showing that the animal must have had an organ equivalent to the eye sufficiently developed to affect the external covering, whether it was adapted for clear vision or not. It may be a family distinction; at all events, the oculate carapaces have to be removed from *Ceratiocaris* and we

propose that M'Coy's *C. elliptica* be referred to a new genus under the name *Emmelezoe.*[1]

E. elliptica, M'Coy, is described in the Third Report, p. 27, as represented by the type, Cambridge Mus. *b*/15; but Ludlow Mus. G, and M.P.G. $X_{\frac{1}{10}}$ and $\frac{22}{32}$ differ from it considerably. The first of these is shorter and broader (higher), nearly semicircular in outline, with an acute and projecting postero-dorsal angle; and its surface has a fine, almost silky, linear ornament. As a new species this might be known as *E. tenuistriata.* The specimen $X_{\frac{1}{10}}$ is subovate, larger than either of the other two, and is coarsely striate, with longitudinal anastomosing wrinklets and might be named *E. crassistriata.* M.P.G. $\frac{22}{32}$ is smaller than any of the foregoing, somewhat boat-shaped, between the last and *elliptica* in shape, but not identical with either; and it is rather coarsely striate longitudinally. To this form we propose to give the name *E. Maccoyiana*, in honour of the first describer of any member of this genus.

21. At page 26 of the Third Report, we described Salter's *Ceratiocaris? ensis*, and now we are still more confirmed in the opinion that it belonged to a distinct genus. Its large size, its curvature, and the serration on both the upper and the lower edge, and the profuse spination (as shown by pits) on the latter distinguish it from other telsons; and more particularly its lozenge-shaped sectional area, of an unequal rhombic form, blunter at the outer (upper) and convex edge than on the other, the ridge along the sides not being quite on the medial line, but nearer the outer than the inner edge. We propose the name *Xiphocaris*[2] for this rare genus.

M. Barrande's *Ceratiocaris primula* (Third Report, p. 32) has a style (or stylet?) with lozenge- or diamond-shaped section; but this uropod, though curved, is of different dimensions, and is pitted all over.

22. *Physocaris vesica*, Salter (Third Report, p. 28) we consider as having had its abdominal segments shifted from below upwards, and turned over on their axis, after death; and therefore as having been figured upside down.

23. Of *C.? lata*, *insperata*, and *perornata* we have no further evidence at present.

24. *Ceratiocaris? longicauda*, D. Sharpe (Third Report, p. 29), a foreign (Portuguese) form within our reach has been studied in the Geological Society's Museum, Burlington House, and shows some interesting features. Its scientific name was given under the supposition that the fossil was a *Dithyrocaris*, with a longer abdomen than usual; but its cylindrical ultimate segment, its somewhat bayonet-shaped style, and blade-like stylets clearly remove it from that genus, as intimated in our former notice. It is probably distinct also from *Ceratiocaris;* it has some analogy with the Devonian *Elymocaris;* but at present we cannot fix its generic place.

25. In the Sitzungsb. K. böhm. Ges. Wiss. 1885, M. Ottamar Novák, Keeper of the Barrande Collection at Prague, has described

[1] Ἐμμελής, elegant; ζωή, life (a termination common in some of M. Barrande's genera).

[2] Ξίφος, a sword; καρίς, a shrimp.

a new Phyllocaridal genus from the *étage* F, f 2, in Bohemia, as *Ptychocaris*, with two species *Pt. simplex* and *Pt. parvula*, characterized by a strong and obliquely longitudinal ridge or sharp fold on each valve, and by an anterior group of three small nodules, an ocular tubercle behind them, and some larger but less distinct

Species of CERATIOCARIS, PHYSOCARIS, XIPHOCARIS, and EMMELEZOE.	Carboniferous Limestone; Oreton.	Ludlow Beds.					Wenlock Beds.			Upper Llandovery; Onny River.	Tremadoc Slates; Portmadoc.
		Upper Ludlow; Ludlow.	Upper Ludlow; Benson Knot, Kendal.	Upper Ludlow; Lesmahago and Muirkirk.	Lower Ludlow; at and near Ludlow.	Upper Shale = Lower Ludlow.	Lower Shale = Wenlock.	Wenlock; Kirkby-Lonsdale.	Lower Wenlock; Helm Knot, Dent.		
						Dudley.					
1. *Ceratiocaris leptodactylus*	—	—	—	—	×	—	—	—	×		
2. *C. Murchisoni*	—	×	—	—	×						
3. *C. gigas*	—	—	—	—	× and Knighton.						
4. *C. valida*	—	—	—	—	—	—	×	×			
5. *C. attenuata*	—	—	—	—	×						
6. *C. canaliculata*	—	×									
7. *C. Halliana*	—	—	—	—	×						
8. *C. Pardoeana*	—	—	—	—	×						
9. *C. ludensis*	—	—	—	—	×						
10. *C. robusta*	—	×	—	—	×						
11. *C. lata*	—	—	—	—	×						
12. *C. angusta*	—	—	—	×							
13. *C. minuta*	—	—	—	—	×						
14. *C. papilio*	—	—	?	× }	×						
15. *C. stygia*	—	—	?	× }							
16. *C. laxa*	—	—	—	×							
17. *C. Salteriana*	—	—	—	—	×	×					
18. *C. cassia*	—	—	—	—	×						
19. *C. cassioides*	—	—	—	—	×						
20. *C. compta*	—	—	—	—	×						
21. *C. decora*	—	—	—	—	Freshwater Pembrokeshire.						
22. *C. oretonensis*	×										
23. *C. truncata*	×										
24. *C. inornata*	—	—	×								
25. *C. Ruthveniana*	—	—	×								
26. *C. solenoides*	—	—	×								
27. *C. gobiiformis*	—	—	×								
28. *C. perornata*	—	—	×								
29. *C. ? lata*	—	—	—	—	—	—	—	—	—	—	×
30. *C. ? insperata*	—	—	—	—	—	—	—	—	—	—	×
31. *C. ?* sp.	—	—	—	—	—	—	—	—	—	×	
32. *Physocaris vesica* ...	—	—	—	—	×						
33. *Xiphocaris ensis* ...	—	—	—	—	×						
34. *Emmelezoe elliptica*	—	—	×								
35. *E. tenuistriata*	—	—	—	—	×						
36. *E. crassistriata*	—	Presteign									
37. *E. Maccoyiana*	—	—	—	—	×						

swellings further back, but still in the antero-dorsal region. M. Novák supplies also a table of the vertical distribution of the *Phyllocarida* in Bohemia.

In the Annales XIII. Soc. Géol. du Nord, 3^{me} Livr. April, 1886, p. 146, M. E. Canu gives a *résumé* of the results of M. O. Novák's researches in the *Phyllocarida*, with some woodcuts of *Aristozoe regina*, *Bactropus longipes*, and *Ceratiocaris debilis* (see Third Report, pp. 32–34), and of *Ptychocaris simplex* (see above).

26. Dr. A. S. Packard, jun., has described and figured some peculiar appearances on an internal cast of a Carboniferous Phyllopodous carapace from Illinois, as traces of four pairs of lamellate limbs (thoracic feet), probably "the homologues of the exopodites of *Nebalia*." He has defined the genus and species as *Cryptozoe problematica* (American Naturalist, Extra, Feb. 1886, p. 156; and Proceed. Americ. Philosoph. Soc. vol. xxiii. No. 123, pp. 380–383).

27. In a Geological Report, Assembly Document, No. 161, 1885 (or 1886), Mr. J. M. Clarke has defined the localities and geological succession in Ontario County and New York, where the Phyllopods which he previously described (see 'Second Report,' 1884, pp. 80–86, and 'Third Report,' p. 3) have occurred with or without Goniatites.

28. A list of the British Palæozoic Phyllocarida described in the Third and Fourth Reports is given on the preceding page (p. 461).

NOTICES OF MEMOIRS.

I.—Records of the Geological Survey of India, vol. xix. pt. 2. 1886.

TWO short papers in this part relate to the disputed age of the beds in the Salt Range, containing species of *Conularia.* The first is "A Note on the Olive Group of the Salt-range," by R. D. Oldham, A.R.S.M., and the other "Memorandum on the Discussion regarding the Boulder-beds of the Salt-range," by H. B. Medlicott, F.R.S. Mr. Oldham visited the locality in the Salt-range, in which the *Conularia* beds occur, and states that the thin band of gravel in which they appear is the last kind of rock in which one would *à priori* expect concretionary nodules to be formed. At the same time he believes that for the most part these fossiliferous pebbles were originally concretionary nodules, and that they have been transported into their present position. From the character of the associated pebbles in the beds beneath, he believes that the original position of the beds from which the *Conularias* come must have been to the southward of where they now are. He further concludes from the stratigraphical relations of the beds, that the Olive group (including the gravel-bed with *Conularia*) is homogeneous, and must be associated with the overlying nummulitic beds, rather than with the underlying Palæozoic or early Secondary beds.

Mr. Medlicott does not admit that the petrological evidence brought forward by Mr. Oldham is altogether conclusive as to the transported origin of the fossiliferous pebbles, though it would be "almost absolute if he could assert that the ground-mass of the gravel-bed is quite different from that of the fossiliferous pebbles in the bed." Further, even supposing the correctness of Mr. Oldham's theory, that the fossiliferous pebbles are concretionary nodules, it does not at all explain the presence of this small special fauna in a distinct bed by itself. Mr. Medlicott asks the following pertinent question: "Is it conceivable that in Upper Cretaceous time, when the abundantly fossiliferous Permian and Secondary deposits were in force in the neighbourhood, and presumably exposed to denudation, if older deposits were so, a special collection of fossils from those older fossils can have been raked together, transported together, and deposited together at a distance, by the promiscuous process of detrital agency?" "So long as special Palæozoic fossils only are found in these beds, their Upper Cretaceous age will be open to doubt."

This argument has great force; and evidence of a more decided character will be required, before the relative age of the *Conularia* beds, and the boulder-beds underlying them, can be regarded as settled. G. J. H.

II.—MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA. PALÆONTOLOGICA INDICA. Ser. xiii. SALT RANGE FOSSILS, by WILLIAM WAAGEN, Ph.D., F.G.S., and JOSEPH PICHL. I. PRODUCTUS-LIMESTONE FOSSILS: 5. BRYOZOA—ANNELIDA—ECHINODERMATA. With ten plates, 87—96.

THE authors reject from the Bryozoa, and regard as Corals, such forms as *Stenopora*, *Monticulipora*, and allied genera. The Bryozoa described belong to the families of the Fenestellidæ and Thamniscidæ. In the first of these families the following species are recorded: *Fenestella perelegans*, Meek, *F. jabiensis*, n., *Polypora Koninckiana*, n., *P. megastoma*, Kon. sp., *P. gigantea*, n., *P. ornata*, n., *P. sykesi*, Kon. sp., *P. biarmica*, Keyser, *P. vermicularis*, n., *P. transiens*, n., *Phyllopora jabiensis*, n., *P. cribellum*, Kon., *P. haimeana*, Kon., *Synocladia virgulacea*, Phill., *Goniocladia indica*, n. In the family Thamniscidæ are ranged *Thamniscus dubius*, Schlot., *T. serialis*, n., and *Acanthocladia anceps*, Schlot. In the Annelidæ, *Spirorbis helix*, King, and *Serpulites indicus*, n., are described. Fragmentary plates and species of *Eocidaris Forbesiana*, Kon., are noted. The following species of Crinoids are present: *Cyathocrinus goliathus*, n., *C. virgulensis*, n., *C. indicus*, n., *C. Battaensis*, *Hydriocrinus*? sp. indt., *Poteriocrinus*, sp. indt., and *Philocrinus cometa*, Kon. The descriptions of these species are very carefully and fully drawn up, and they are excellently illustrated in the accompanying plates. G.J.H.

III.—NOTICE SUR LE PARALLÉLISME ENTRE LE CALCAIRE CARBONIFÈRE DU NORD-OUEST DE L'ANGLETERRE ET CELUI DE LA BELGIQUE; par L. G. DE KONINCK et MAXIMIN LOHEST. (Bruxelles, Bulletins de l'Académie royale de Belgique, 3^{me} série, t. xi. No. 6, 1886.)

ONE of the authors has lately examined the horizontal beds of conglomerate of white quartz pebbles in a calcareous matrix, which, in the neighbourhood of Ingleborough, rest unconformably on Silurian strata, and form there the base of the Carboniferous system. The fossils in these beds comprise, amongst others, *Lithostrotion basaltiforme*, species of *Amplexus* and *Zaphrentis*, and teeth of Placoids, some of which are recognized as *Lophodus lævissimus*, Ag., and *Copodus cornutus*, Ag. Resting on the conglomerates are grey limestones with an abundance of *Chonetes papilionacea*, Phill. In these, and the beds below, *Productus giganteus* is conspicuously absent, whilst it is extremely abundant in the limestone beds of the series above. In the Belgian Carboniferous Limestone series there are no conglomerates like those at Ingleborough, but at the base of the limestones with *Productus giganteus* and *P. cora*, forming the 'Calcaire de Visé,' there are some beds distinguished by the abundance of *Chonetes papilionacea*, and between these and the Upper Devonian strata there is a great thickness of beds containing Corals and Placoid teeth, analogous to those in the Ingleborough Conglomerates, and the authors therefore conclude, that these Lower Limestones, beneath the Calcaire de Visé, are represented in part by the Yorkshire Conglomerates, which are not more than about 180 feet in thickness. On the other hand, the zone of *Productus giganteus* in the north of Yorkshire attains a much greater thickness than in Belgium.

G. J. H.

IV.—FIFTH ANNUAL REPORT OF THE UNITED STATES GEOLOGICAL SURVEY, 1883–84. By J. W. POWELL, Director. 4to. pp. 469, 58 Plates and 143 Figures. (Washington, Government Printing Office, 1885.)

AT the beginning of this massive volume the Director of the Survey gives an epitome of the work carried out, together with the financial statement, from which it appears that the year's expenditure for the Survey amounted to nearly 330,000 dollars, or about £67,300. This is followed by brief administrative reports of chiefs of divisions and heads of independent parties, from which an idea may be formed of the extent and variety of the operations included in the Survey. Thus, the chief geographer, Mr. Henry Gannett, reports that topographical field work had been actively carried on by different parties in Northern California, Arizona, New Mexico, Montana, the Yellowstone Park, Massachusetts, the Denver District of Colorado, and part of the Elk Mountains. The party under the charge of Mr. Arnold Hague was engaged in working out the geology of the Yellowstone National Park, and studying the physics of geyser action in that district. Mr. T. C. Chamberlain reports on the investigations made by himself and others under him in tracing out the moraines and other glacial deposits in the upper valleys of the Mississippi and Missouri, in Dakota, and also in Illinois, Indiana, Ohio, and Kentucky. The division under Prof. Roland D. Irving is engaged in a general investigation of the Archæan formations of the North-western States, and its field of operations extended from Northern Michigan to the country on the north-west of Lake Superior. Dr. F. V. Hayden studied the relations of the Laramie Group and other Cretaceous rocks, exposed between the Missouri at Bismark, Dakota, and the Yellowstone at Glendive, Montana. Mr. G. K. Gilbert and his assistants carried on their work of investigating the Quaternary Lakes of the Great Basin in Utah and California. Mr. W. J. M'Gee reports on the progress made in preparing a general geological map of the United States, as well as on his studies of the superficial deposits of the district of Columbia and adjacent territory. Captain C. E. Dutton is engaged in studying the chain of volcanoes constituting the Cascade Range in California, Oregon, and Washington Territory. Mr. S. F. Emmons reports on mining geology of the Rocky Mountains, and Mr. G. T. Becker on the quicksilver mining district of Knoxville in California. Prof. O. C. Marsh states that eight different parties were engaged in collecting fossils in Oregon, Wyoming, Kansas, and Nebraska, and that his monographs on the *Sauropoda* and the *Stegosauria* were in course of completion. Dr. C. A. White was engaged in studying the Laramie Group on the Upper Missouri, and on various palæontological investigations in Washington and California. Mr. C. D. Walcott, assisted by Prof. H. S. Williams and others, has studied the Devonian and other Palæozoic rocks of New York, Tennessee, Virginia, Vermont and Alabama. Mr. Lester F. Ward has been collecting and arranging the fossil plants of the Fort Union Group on the Yellowstone and Upper Missouri rivers. The chemical work of the Survey is directed by Mr. F. W. Clarke, whilst Mr. A. Williams is engaged on the statistics of metals; and, finally, Mr. G. W. Shutt traces the course of a preliminary geological investigation in Virginia.

These administrative reports, however, only occupy sixty-six pages of the volume; the remaining 400 pages contain a series of elaborate essays on different branches of geological science, each of which is treated in considerable detail, and abundantly and beautifully illustrated. We can here but mention the titles of the different treatises and the authors' names, and refer the reader to the volume itself. The first treatise is on "The Topographic Features of Lake Shores," by G. K. Gilbert. This is followed by "The Requisite and Qualifying Conditions of Artesian Wells," by T. C. Chamberlain; "Preliminary Paper on an Investigation of the Archæan Formations of the North-Western States," by R. D. Irving; "The Gigantic Mammals of the Order Dinocerata," by Prof. O. C. Marsh; "Existing Glaciers of the United States," by T. C. Russell; and "Sketch of Palæobotany," by Lester F. Ward.

G. J. H.

REVIEWS.

Department of the Interior. Report of the United States Geological Survey of the Territories. F. V. Hayden, United States Geologist-in-Charge. Volume III. The Vertebrata of the Tertiary Formations of the West. Book I. By Edward D. Cope, Member of the National Academy of Sciences. (Washington, Government Printing Office, 1883.)

(*Continued from p.* 419.)

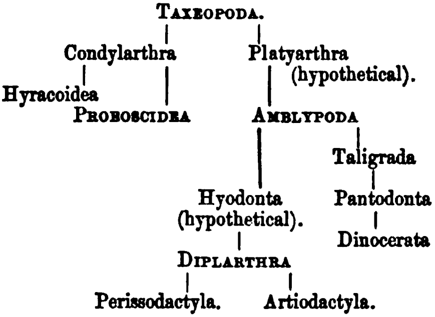
BATS are scantily represented in the Bridger fauna, the only American species described by Professor Cope being *Vesperugo anemophilus*, which has the inferior molars like those of *Didelphys.*

We now turn to the group division of hoofed mammals. The first order, which the author names TAXEOPODA, comprises animals, in which the carpus and tarsus form two rows, with the bones of the first row supported by the second row, each for each, so as not to alternate. The order is defined as having the scaphoid bone supported by the trapezoid, and the lunar bone supported by the magnum. The cuboid bone articulates proximally only with the calcaneum. This group comprises the HYRACOIDEA, in which the fibula articulates with the astragalus, and the ungual phalanges are truncate; secondly, the CONDYLARTHRA, in which the fibula does not articulate with the astragalus or calcaneum, and the ungual phalanges are pointed. A third group may be formed by the TOXODONTIA, or the Toxodontia may belong to the Proboscidea.

The AMBLYPODA is an order which is subdivided into two groups, first, *Pantodonta*, which has a third trochanter to the femur, and incisor teeth in the upper jaw; and secondly, *Dinocerata*, which has no upper incisors, and no third trochanter. The Amblypoda are defined from the Proboscidea, chiefly by the shortness of the navicular bone, which allows the cuboid bone to articulate with the astragalus.

The name DIPLARTHRA is used as an ordinal name for the Perissodactyla and Artiodactyla, in place of the name Ungulata, which is made to include all hoofed mammals.

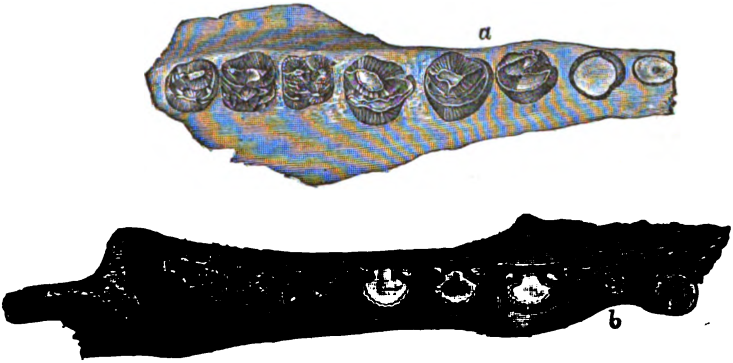
This classification is exhibited in the following diagram:—



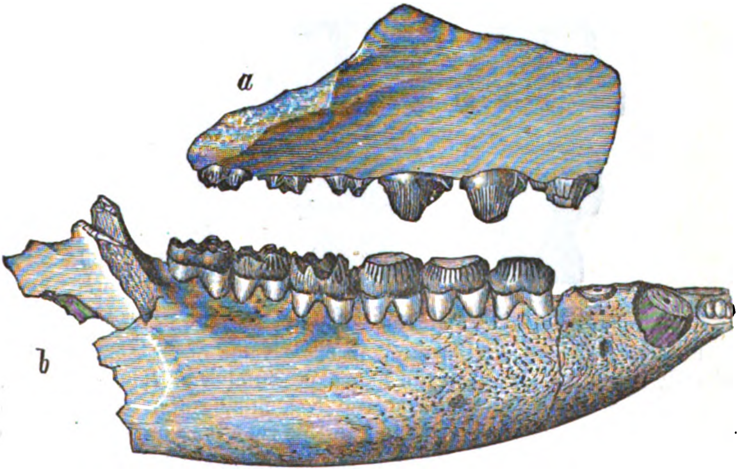
The carpal modification which characterizes the Diplarthra is explained as a rotation of the bones of the second carpal row upon those of the first row, in which they move to the inner side, a condition attributable to the loss of the pollex, by which the weight of the body is thrown chiefly on the third and fourth digits. And seeing that this condition has brought about the alternation of the two rows of carpal bones, producing a stronger carpus, the author is disposed to regard the modification as accounting for the survival of the Diplarthra, while most of the mammals which have a serial arrangement of the carpal bones have become extinct.

The Amblypoda is intermediate between the Taxeopoda and Diplarthra, in having the carpus of the more complicated type. The Taxeopoda approach most nearly to the Bunotheria, especially the Mesodonta, from which they are distinguished by their hoofs, though some Creodonts like *Mesonyx* have claws which are almost hoofs in character.

The Condylarthra comprise three families; they are primitive ungulates, with five-toed, plantigrade feet, with the astragalus like that of the Creodonta and Carnivora, and have other characters known only among Unguiculates. The lowest representative of this group is the Periptychidæ. It comprises four genera. In *Periptychus* the inferior premolar teeth have internal lobes, while in the other genera, *Anisonchus*, *Hemithlæus*, and *Haploconus*, the internal lobes are wanting. The crowns of the true molars have seven tubercles; the canines are of moderate size, and the inferior incisors small.



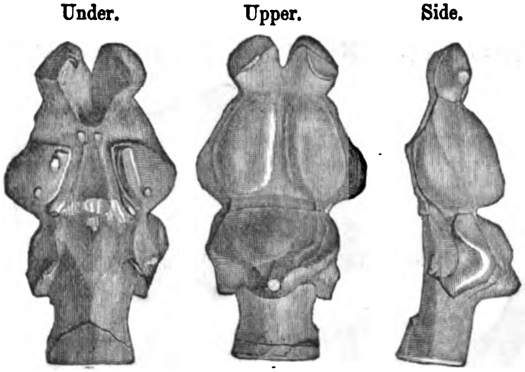
Upper Jaw (*a*). Mandible (*b*). *Periptychus rhabdodon.*



Periptychus rhabdodon.

The true molars in the mandible have four principal cusps, in opposite pairs, with accessory median cusps in front and behind. The angle of the lower jaw is not inflected, and the coronoid process rises near to the condyle. The cerebral hemispheres are long and narrow, divided by a long flat crus from the olfactory lobes, which are nearly as wide as the cerebral hemispheres. The affinities of this type are not, however, regarded as absolutely determined. The premolar teeth have a sculpture which is not unlike that seen in the fourth premolar of *Ptilodus*, yet there are no other reasons for supposing it to be marsupial. The characters of the astragalus are not unlike those seen in the Creodonta, but other structures indicate that it was probably ungulate. Three species are known, among which *P. rhabdodon* is fully described. Its cervical vertebræ are as short as in the Elephant. The humerus especially, in its small tuberosities, suggests the Proboscidea, though the animal was only about the size of the Collared Peccary, and is thought to have had much the aspect of the short-necked Bear. The teeth indicate omnivorous habit. It is the most abundant Mammal of the Puerco beds. Many of the other types in this family like the species of *Hemithlæus*, *Anisonchus*, and *Haploconus*, are known from little more than the dentition, which varies in the number and form of the cusps of the upper molar and premolar teeth.

The Phenacodontidæ is an allied group of four genera, in which the teeth have much the same general plan as that just described. *Protogonia* has but one external lobe in the upper premolar teeth. In *Phenacodus* the fourth premolar has two external lobes, while in *Diacodexis* the two external lobes are found in the second, third, and fourth teeth.



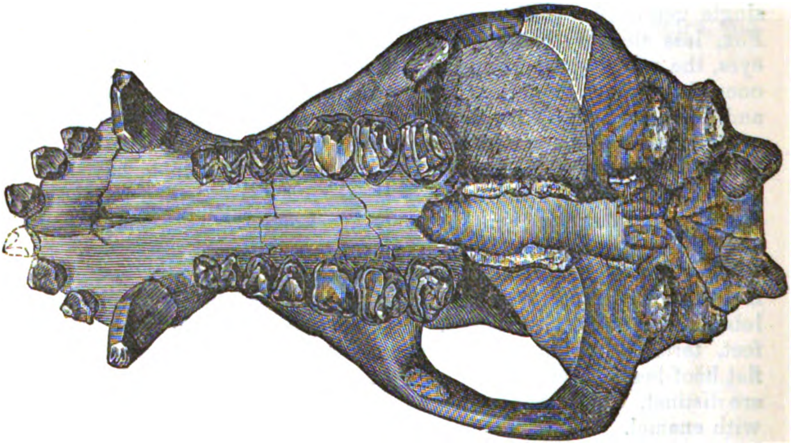
Brain of *Phenacodus primævus.*

Professor Cope's earlier and brief account of *Phenacodus* has already been reproduced in the February Number of this Magazine. The detailed description now given is a monograph extending to more than sixty pages. The skull in this type is remarkable for the anterior shortening of the nasal bones, so as to give a superior aspect to the nostrils, and these bones extend back closer to the orbit than is usual in Eocene genera, making a slight approach to the Tapir. The slender premaxillary bones are not united in front; and the rami of the mandible have no bony union. The cerebral hemispheres are unusually small, being only one-fourth longer than the cerebellum, from which they are separated by a thick tentorium. In the same way, deep grooves divide the hemispheres from each other, and from the olfactory lobes in front. Nine species are recognized, seven of which are defined by the characters of teeth in the mandible. In the description of *P. Vortmani* indications are given that the spine of the scapula is recurved, as in the Amblypoda and Proboscidea; while the bone differs chiefly from that of the Dinocerata and Proboscidea in the addition of an acromion, which gives a resemblance to some Rodents like the Squirrel. The tuberosities of the humerus are less developed than in most Diplarthra. The proportions of the ulna and radius are similar to those of *Hyrax*, but the distal articulation of the ulna is like that of a Carnivore. The pelvis is intermediate between that of *Hyrax* on the one hand and *Canis* and *Ursus* on the other. The femur is rather more robust than that of the Tapir. The astragalus is small, and resembles that of *Hyrachyus*. This species was about as large as a Bulldog, but with a smaller head and shorter neck, which had more the proportions of a Raccoon. The feet resembled those of the Tapir or Rhinoceros, but with a pair of short toes on each side which did not reach the ground. The tail was like that of a Dog.

The third family of Condylarthra, Meniscotheriidæ, includes the single genus *Meniscotherium*. The animal was about as large as a Fox, less slender than *Phenacodus*, with a short muzzle and large eyes, the robust proportions of a Raccoon, and a large tail. It was one-third larger than the Cape Hyrax, probably a vegetable feeder. and distinguished by its dentition. The upper molars have intermediate tubercles, of which the anterior are crescent-shaped, the posterior oblique. The inferior molars and last premolar have two V-shaped folds. The brain cavity is relatively larger than in *Phenacodus*. Three species of the genus are known. The comparisons chiefly indicate relations with *Phenacodus* and *Hyracotherium*.

The Amblypoda next claim attention. This group comprises mammals with small cerebral hemispheres, which leave the olfactory lobes and cerebellum exposed. The species have short plantigrade feet, terminating in the known genera in five digits, which have flat hoof-bearing terminal phalanges. The seven bones of the carpus are distinct. The molar teeth have wide crowns and crests invested with enamel. The structure of the feet indicates an affinity to the Proboscidea, which is most obvious in the hind foot, the principal difference being that, while the navicular bone extends over the distal end of the astragalus in Proboscidea, the navicular bone is so short in Amblypoda as to allow the cuboid to come in contact with the astragalus. The nearest approach to this condition of the Amblypoda is seen in the Miocene Perissodactylate genus *Symborodon*, where the cuboid and navicular facets are flat, and separated by an oblique line, so as to be similarly incapable of hinge-like movements. In the fore foot the difference between Amblypoda and Proboscidea consists in the alternating position of the elements of the two carpal rows. This alternating condition is usual in the cold-blooded

Vertebrata; and is characteristic of the other existing orders of hoofed Mammals, while in the Proboscidea and Hyracoidea the elements of the two rows of carpal bones have an opposite and longitudinal mode of arrangement. In Amblypoda the plan of construction of the fore foot is about equally related to Proboscidea, Perissodactyla, and Artiodactyla. The brain shows affinities with Cheiroptera, Insectivora, and Edentata. In this relation, the forms of the teeth in some Insectivora show interesting resemblances to the fossil genera *Coryphodon* and *Bathyopsis;* while the small smooth cerebral hemispheres and relatively large size of the optic and olfactory lobes in Amblypoda make a nearer approximation to the Creodonta than to any existing group of Mammals. On the whole, the Amblypoda are to be classed as the most generalized order of hoofed Mammalia. They preceded the other groups in time, and may therefore hold an ancestral relation to them. The order is divided into two suborders; first, the Pantodonta, which has superior incisor teeth and a third trochanter to the femur; secondly, the Dinocerata in which both these characters are absent. Both groups have short cervical vertebræ without ball and socket-joints, intermediate in character between those of Proboscidea and other Ungulates,—characters with are repeated in the scapula, ilium and many details of the skeleton.



Skull of *Coryphodon elephantopus*, ⅔ natural size, seen from below.

The Pantodonta in America comprises five genera, *Bathmodon*, *Ectacodon*, *Manteodon*, *Coryphodon*, and *Metalophodon*, and are limited at present to the Wasatch beds in the Rocky Mountain region. *Metalophodon* may possibly be identical with *Bathmodon*, since its feet are at present unknown. In the Pantodonta the symphysis of the mandible is furnished with teeth. The upper surface of the astragalus is flat or concave in the middle, and turned inward; it has a large vertical fibular facet,—characters which are shared with the Dinocerata. The coracoid process of the scapula is produced into a curved hook. The neck is longer than in the Dinocerata.

The genus *Manteodon* has two interior cusps to the last upper molar tooth, and all the upper molars have a marked V shape. *Ectacodon* has only one inner cusp, and one external cusp to the last upper molar, while only the two anterior molars have the posterior V form. *Coryphodon* has no external cusp; and the astragalus is transverse, with an internal hook. This genus is thought to have resembled the Bears in aspect more than any living animals, except that their feet were more like those of the Elephants. The feet indicate a heavy elephantine type of movement, owing to the inflexibility of the ankle. The species varied in size between the bulk of a Tapir and that of an Ox; they were omnivorous, though armed with tusks in both jaws, which are fully as marked as those of Carnivora. There are about twelve American species, some of which are well known from New Mexico. They are distinguished chiefly by relative length of the premaxillary bones, and variations in development and form of the cusps and tubercles of the teeth.

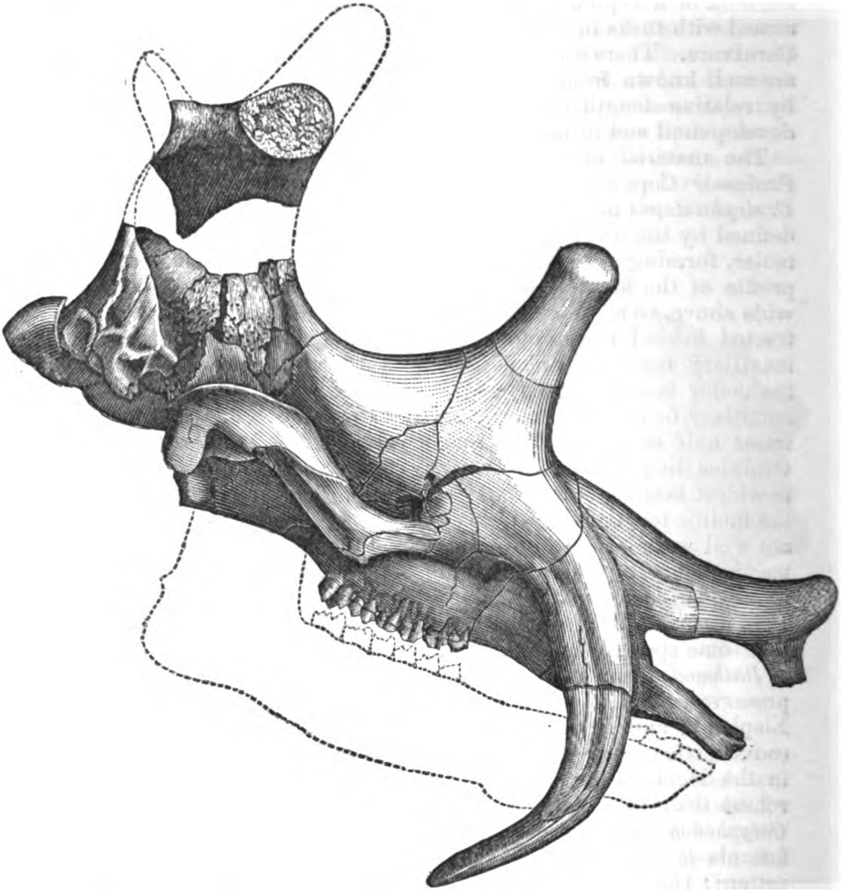
The material for an account of this genus is less full than in Professor Cope's report in Lieut. Wheeler's survey. The species *C. elephantopus* most nearly approaches the genus *Manteodon*, and is defined by the inner half of the posterior crest of the hinder upper molar, forming a V shape, like that of the penultimate molar. The profile of the skull is Tapiroid; the frontal and parietal bones are wide above, so as to overhang the temporal fossæ. The jaw is contracted behind the canine teeth, and the expansion of the premaxillary region is rounded. The zygomatic arch widens, so that the malar bone is carried out laterally far beyond the plane of the maxillary bone. All traces of sutures are obliterated, and the posterior half of the head is roughened above by shallow pits and wrinkles like those seen in many Reptiles. The palatal surface is widest between the posterior incisors. The interspaces between the incisor teeth are as wide as their roots. The large canine teeth are well worn on the anterior face, and the molars are well worn by mastication. *Bathmodon* is an allied genus, in which the astragalus is subquadrate, narrower, and wants the internal hook seen in *Coryphodon*. At present the skull is unknown, and it is possible that some species of *Coryphodon* may belong to this type.

Bathmodon pachypus is the only Coryphodont with the pelvis well preserved. The wide peduncles of the ilia resemble those of the Elephant; and if the crest of the ilium of the Camel were more convex, it would resemble *Bathmodon*. The peduncle is stouter than in the Horse, Tapir, or Pig. The limb bones appear to be more robust than in species of *Coryphodon*. *Metalophodon* differs from *Coryphodon* in the structure of its molar teeth, though the dental formula is the same. All the premolars have the single external V pattern; the first upper molar only has two external Vs, of which the anterior is represented by a subconical cusp, while the posterior V is large. The genus is known from two species.

The next suborder, Dinocerata, is especially distinguished from the

Proboscidea by the small size of the cerebral hemispheres, and the double distal articulation of the astragalus, in which the facets for the cuboid and navicular bones are nearly equal. There is less difference between the molar and premolar teeth in this group than in the Pantodonta. In the upper jaw the crowns of the molars have crests with a V pattern, and the lower molars consists of a V directed outward, and a heel. Professor Cope recognizes four genera based on characters of the mandible; these are named *Eobasileus*, *Loxolophodon*, *Bathyopsis* and *Uintatherium*. *Eobasileus pressicornis* and *E. furcatus* represent the type in which some of the cervical vertebræ are flat and short as in Proboscidea. The muzzle is short; the occipital and parietal crests are remarkably developed, and the proportions of the head somewhat resembled those of Rhinoceros, though the horns and tusks give it a different aspect. *Loxolophodon* is one of those genera concerning which the priority of nomenclature is

Loxolophodon cornutus.



disputed, the author claiming to have named it 19th August, 1872, while he finds no earlier date for the *Tinoceras* of Marsh than the following month; but Marsh claims to have published his name on the same day. *Loxolophodon* has a long compressed head with a roof-shaped muzzle, over which is a bilobed protuberance at the end of the nasal bone. A second pair of horns stands over the orbits, each formed externally from the maxillary, and internally from the nasal bone. Behind this the margin of the temporal fossa rises in a way that is considered to indicate another horn. Three species, *L. cornutus*, *L. galeatus* and *L. spierianus*, are distinguished by characters of the horn-cores.

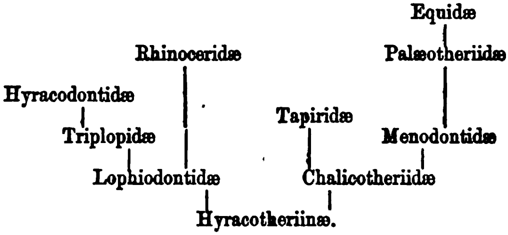
Loxolophodon cornutus has a narrow cranium four times as long as its middle width. The diverging horn-cores are in front of the middle length, each with a triangular base. The frontal bones descend behind the horns. There is no bony septum between the anterior nares. The teeth are remarkable for the exposure of their slender roots, as well as for their small size. The grinding surface of the first premolar tooth appears to consist of a worn crescent and an inner tubercle, while the other premolars are transversely arrow-shaped. All the molars have three roots. This type was similar in form and proportion to the Elephant, with somewhat shorter stouter limbs, and a small tail. The neck was a little longer than in Elephants, but shorter than in the Rhinoceros type. The animal stood almost six feet high at the rump, while the height at the anterior limb is estimated at seven feet five inches. The individual from which these measurements are taken may not, however, have reached its full size. Teeth indicate it to have been a vegetable feeder. It is remarkable that the orbits have no distinctive outline, while the eyes were so overhung by the horns that the view was chiefly lateral, for the muzzle and cranial crest obstructed the view in front and behind. This species was found in the bad lands of Wyoming, 8500 feet above the sea.

Uintatherium has the cervical vertebræ more elongated. This genus is regarded by the author as identical with that which Professor Marsh has rendered classical as *Dinoceras*, though Professor Marsh separates *Dinoceras* from it as having three instead of four lower premolars. Leidy published *Uintatherium* in August, 1872; Marsh, *Dinoceras*, in September, 1872. Three species are here described. Another genus, *Bathyopsis*, is founded on a mandible with the three molar teeth and four premolars constructed on the same pattern. It differs from *Uintatherium* and *Loxolophodon* in the much greater vertical depth of the inferior expansion of the ramus of the mandible, along the whole length of which it extends. The inferior molars are constructed on the plan of those of insectivorous and marsupial Mammals, so as to suggest that the animals fed on Crustacea, large Insects, and perhaps thin-shelled Molluscs.

A third suborder of the Amblypoda named Taligrada is believed to be indicated by a single species of a genus *Pantolambda*. This suborder is defined chiefly on the characters of the astragalus, for while that bone in the Pantodonta has no head, in this type it has a head distinct from the trochlear and distal articular facets. The cusps of the upper and lower molars develope into Vs. All the vertebræ have flat articulations. There is no inter-trochlear ridge to the humerus; and the femur has a third trochanter. Excluding the characters of the astragalus, there are resemblances to the Condylarthra in the narrow ilium, and in the molar teeth having but one internal lobe; but the dentition is especially like that of the Amblypoda, and there are resemblances to the Pantodonta in the premaxillary teeth, the short flat cervical vertebræ, and the third trochanter to the femur; but the characters of the astragalus are rather like those of the Periptychidæ and the Proboscidea. In *Pantolambda* the brain indicates small nearly smooth hemispheres, extending with little contraction into a rather large cerebellum, while the olfactory lobes are produced anteriorly at the extremity of a rather long isthmus. The dentition would indicate *Pantolambda* to be the ancestor of the Coryphodonts. The superior molars are all triangular from having a single internal cusp. This type of tooth at the present day is found among Insectivorous and Carnivorous Marsupials, in the Insectivora, and in the tubercular crowns of some Carnivora; and among Ungulates it is found in the molars of the Coryphodonts, and in the last upper molar of the Dinocerata. The only species is *Pantolambda bathmodon*, in which the hinder part of the skull is Opossum-like, and the nasal bones give an obtusely roof-shaped form to the muzzle.

The Perissodactyla are well represented in the North American Tertiaries. The group may be described as intermediate in dentition between the Proboscidea and the lowest Selenodont Artiodactyla. On dental characters Professor Cope recognizes ten families arranged into four divisions. First, animals with the anterior crescent of the upper molars shortened, and not distinguished from the posterior crescent by an external ridge, with cross-crests to the inferior molars, and with premolars distinct from the molars. This comprises the Lophiodontidæ, in which the toes are 4–3; and the Triplopodidæ, in which the toes are 3–3. Secondly, a division in which, while the exterior crescents of the upper molars, and the cross-crests of the lower molars, remain as in the first division, while the upper molars and premolars are alike, and furnished with cross-crests. Under this type are comprised the Hyracodontidæ, in which the mastoid bone enters into the external wall of the skull; and the Rhinoceridæ, in which the mastoid bone is excluded from the wall of the skull, by contact of the squamosal bone with the occipital bone. The third division has the exterior crescentic crests of the upper molars subequal and distinct, with cross-crests to the inferior molars. This type comprises the Tapiridæ, in which the upper molars and premolars are alike furnished with cross-crests, and with the toes 4–3. The last division has the nearly equal external crescentic crests of the upper molars separated by an external ridge, while the inferior molars are furnished with crescents. First in this group are placed the families with superior premolars different from the molars, and with only one internal cusp. The

Chalicotheridæ have the toes 4–3, and the Macrauchenidæ have the toes 3–3. And secondly come families in which the molars are like the premolars, but with two internal lobes; and among these the Menodontidæ have the digits 4–4, the Palæotheriidæ have the digits 3–3, while the Equidæ have the digits 1–1. These families include 46 genera and 192 species. The author remarks that the Lophiodontidæ and Chalicotheridæ are prevalent in the Eocene; the Rhinoceridæ and Palæotheriidæ characterize the Miocene; while the Tapiridæ and Equidæ are chiefly found in the latest Tertiary epochs. The following table exhibits the relations of the families with each other.



The Lophiodontidæ comprises a large number of species, all of which, with one exception, are limited to the Eocene rocks. Among living animals the Tapirs most nearly resemble them. They range in size from that of a Rabbit to the bulk of an Ox. *Lophiodon* is limited to Europe; *Hyrachyus*, *Hyracotherium* and *Pliolophus* to Europe and North America; while *Systemodon*, *Heptodon*, *Helaletes*, and *Colonoceras* are only found in North America. All these genera are classified and defined by dental characters. *Systemodon* is allied to *Hyracotherium* and *Pliolophus*; but instead of having the wide diastema behind the canine tooth, seen in *Hyracotherium*, there is no interspace at all. The dental formula appears to be the same, and the differences are in the form and arrangement of the cusps. The genus is represented by two species.

Hyracotherium is admirably known from six American species; it shows three diastemata, behind the third incisor, the canine, and the first premolar in the upper jaw; and two in the lower jaw, behind the canine, and the first premolar. The species of this genus differ in the relative development of the intermediate tubercles of the upper molars, in the distinctness of the tubercles of the lower molars, the varying lengths of the diastemata, and the development of the cingula. The form of the head is very like *Anchitherium*, and the cingulum of the upper molar teeth is represented in *Anchitherium* by a ledge, while the principal bones of the limbs are much alike in both genera, so that there are some grounds for suggesting an ancestral relation between them. The coracoid process of the scapula in *Hyracotherium* is incurved as in *Coryphodon* and *Anchitherium*, and is larger than in its allies *Triplopus* and *Hyrachyus*. The humerus, especially in its proximal end, has much in common with these genera, and in the simple groove for the biceps is like *Tapirus* and *Anchitherium*. The carpus includes eight bones, and is more like that of *Hyrachyus* than

Triplopus, owing to the second metacarpal having a considerable contact with the os magnum. The bones of the hind limb have most resemblance with *Hyrachyus*; but the femur of *Hyracotherium* has the great trochanter larger, so as to project far above its head. The third trochanter is large, but not so long as in the Tapir and the Horse. The species range in size from *H. index*, which is equal to the Kit Fox, to *H. craspedotum*, which is equal to the Coyote. Three species are found in the Wasatch beds, three in the Wind River beds, and one in the Bridger beds.

The genus *Pliolophus* is said to differ from *Hyracotherium* only in having two tubercles on the heel of the fourth premolar tooth instead of one. The genus is intermediate between *Hyracotherium* and *Lophiotherium*. Six species have been defined, including Professor Owen's original type, and five of these are North American. The genus *Heptodon* is essentially a Lophiodon with seven superior molars: three species are now described. *Hyrachyus* has no heel to the last true molar; its lower canines form a continuous series with the incisors, but are separated from the premolars by a diastema. The affinities of the skeleton are, first, with the Rhinoceros type; secondly, with the Tapirs, and least with the Horses. Equine characters are seen in the articulation of the lumbar vertebræ, Rhinocerontic characters in the form of the sternum; but the affinities are strongest with *Hyracotherium*. The carpal articulation of the ulna is not so small as in *Triplopus* and *Anchitherium*. Nine species have been recognized; three are fully described, and the author points out in detail the differences between *Hyrachyus eximius* and *Tapirus roulini*. *Triplopus* is a genus nearly allied to *Hyrachyus* in its dentition, but appears to have a third transverse crest in the first true molar, and there is a difference in the number of digits in the fore foot. The rudimental character of the fifth metacarpal, which in *Hyrachyus* is well developed, and carries a digit, is the ground for making *Triplopus* the type of another family. It is regarded as connecting the Lophiodonts with the Rhinoceroses; but the structure of the true molars and the character of the feet place it between those families. Only one species is known with certainty.

A synopsis is given of the generic characters of the Rhinoceridæ, based on the number of digits, the dentition and the conditions of the skull connected with the development of horns. The Tapiridæ is in the same way briefly defined, but no species of either group is described.

The Chalicotheriidæ is a group of eight genera. The symmetrical external Vs of the upper molars and the double Vs of the inferior molars distinguish them from the Lophiodontidæ; but they are not so clearly defined from the Menodontidæ. Among its genera, *Pachynolophus* and *Chalicotherium* are found in Europe, *Nestoritherium* in Asia, while North America yields *Ectocion*, *Leurocephalus*, *Palæosyops*, *Lymnohyus* and *Lambdotherium*, all of which are defined by dental characters. *Ectocion* is only known from the teeth; *Palæosyops* differs from *Palæotherium* in the isolation of the internal cones of the upper molars from the external longitudinal crescentic crests, and in having but one inner tubercle instead of two on the last three premolars. The molar dentition approaches towards *Menodus.* The pelvis was more Palæotheroid than Tapiroid. This genus, which is limited to the Eocene, is illustrated by descriptions of four species. *Limnohyus* differs from the type last mentioned in having two conical tubercles instead of one on the inner series in the last upper molar. Two species are described. *Lambdotherium* is only known from its dentition; and the author remarks that if the ridges which are rudimented in the molars of *Hyracotherium* were developed, and the external cusps of the superior molars flattened externally, the result would be the dentition of *Lambdotherium.* Three species are described. Brief notices follow, without description of species, of the genera contained in the Macraucheniidæ, Menodontidæ, Palæotheriidæ and Equidæ.

The Perissodactyla in the Eocene rocks of the Western Territories are thus seen to exhibit many and varied types, but the Artiodactyla are scantily developed in the Eocene period. Only two or perhaps three genera of Hogs have come under Professor Cope's notice, and *Pantolestes* is the only type described. The tarsal characters are in general similar to those of *Dicobune,* but this genus differs in having but one inner tubercle to the upper molars and one external tubercle to the upper premolars, and differs from the Anoplotheres in the presence of external digits. Seven species are defined and described. This concludes the account of about 250 species of Eocene Vertebrata, though supplements include descriptions of a few Fishes, Reptiles, Birds, and Mammals, which were received too late to be comprised in the body of the work. A notice of the Miocene fauna from the White River and John Day beds must be reserved for another notice, after which it may be convenient to discuss the scientific results of the author's work.

H. G. Seeley.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science. Fifty-sixth Meeting, Birmingham, 1886.

Section C.—Geology.

President :—Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S.

Vice-Presidents :—Professor C. Lapworth, LL.D., F.G.S.; H. Woodward, LL.D., F.R.S., F.G.S.; Rev. H. W. Crosskey, LL.D.; Sir Julius Von Haast, K.C.M.G., D.Sc., F.R.S.; Prof. E. Hull, LL.D., F.R.S.; W. Mathews, M.A., F.G.S.; Dr. A. R. Selwyn, C.M.G., F.R.S.

Secretaries :—W. Jerome Harrison, F.G.S.; J. J. H. Teall, M.A., F.G.S.; W. Topley, F.G.S. (*Recorder*); W. W. Watts, B.A., F.G.S.

Titles of Papers read September 2nd to 8th, 1886.

Address by the President.

Prof. C. Lapworth.—Geology of the Birmingham District.

W. J. Harrison.—On the Discovery of Rocks of Cambrian Age at Dosthill, in Warwickshire.

Prof. C. Lapworth.—The Cambrian Rocks of the Midlands.

W. H. Waller.—On the Petrography of the Volcanic and associated Rocks of Nuneaton.

A. Strahan.—On the Rocks surrounding the Warwickshire Coal Field, and on the base of the Coal-Measures. With an Appendix on the Igneous Rocks of the Neighbourhood, by *F. Rutley.*

W. Matthews.—On the Halesowen Coal Boring.

F. G. Meacham and H. Insley.—On the Thick Coal and the Trias north of Birmingham, and on the old South Staffordshire Coal Field.

Dr. H. W. Crosskey.—Report on the Erratic Blocks of England and Wales.

Dr. H. W. Crosskey.—On the Glacial Formations of the Birmingham District.

Rev. W. Tuckwell.—On the Glacial Erratics of Warwickshire and Leicestershire.

A. T. Evans.—The Fossiliferous Bunter Pebbles contained in the Drift of Moseley, etc.

Prof. W. Benton.—On the Surface Subsidences caused by Coal Mining.

Dr. H. Woodward and R. Etheridge.—To exhibit some Organisms met with in the Clay-Ironstone Nodules of the Coal-Measures of the Neighbourhood of Dudley.

S. A. Adamson.—Notes on the Discovery of a large Fossil Tree in the Lower Coal Measures at Clayton, near Bradford.

Rev. P. B. Brodie.—On the Discovery of Fossil Fish in the New Red Sandstone (Upper Keuper) in Warwickshire.

Rev. P. B. Brodie.—On the Range, Extent, and Fossils of the Rhætic Formation in Warwickshire.

W. J. Harrison.—On a Deep Boring for Water in the New Red Marls (Keuper Marls) near Birmingham.

Dr. W. T. Blanford.—Notes on a Smoothed and Striated Boulder from a Pretertiary Deposit in the Punjab Salt Range.

A. B. Wynne.—On a Facetted and Striated Pebble from the Olive Conglomerate of Chil Hill, in the Salt Range, Punjab.

Prof. E. Hull.—Notes on the Problems now being investigated by the Officers of the Geological Survey in the North of Ireland, chiefly in Co. Donegal.

Dr. C. Callaway.—Notes on the Crystalline Schists of Donegal.

Prof. C. Lapworth.—The Ordovician System in Shropshire.

Prof. T. McK. Hughes.—On the Silurian Rocks of North Wales.

Prof. T. McK. Hughes.—Notes on some Sections in the Arenig Series of North Wales and the Lake District.

J. E. Marr.—On the Lower Palæozoic Rocks, near Settle.

A. J. Jukes-Browne.—Note on a Bed of Red Chalk in the Lower Chalk of Suffolk.

Dr. C. Le Neve Foster.—Manganese Mining in Merionethshire.

J. W. Davis.—On the Exploration of Raygill Fissure, Yorkshire.

C. Beale.—On the Dolerites of Rowley Regis.

C. J. Woodward.—On the Mineral District of Western Shropshire.

F. D. Adams.—On the Anorthosite Rocks of Canada.

Prof. H. Carvill Lewis.—On a Diamond-bearing Peridotite, and on the Genesis of the Diamond.

J. J. H. Teall.—On the Metamorphosis of the Lizard Gabbros.

Prof. J. F. Blake.—Introduction to the Monian System of Rocks.

Prof. J. F. Blake.—On the Igneous Rocks of Llyn Padarn, Yr Eifl and Boduan.

J. H. Player.—On an accurate and rapid method of estimating the Silica in Igneous Rocks.

J. Hopkinson.—On a new form of Clinometer.

H. B. Stocks.—On Concretions.

W. Pengelly.—On a Scrobicularia Bed, containing Human Bones, at Newton Abbot, Devonshire.

W. W. Watts.—The Corndon Laccolites.

Prof. T. Rupert Jones.—Report on the Fossil Phyllopoda of the Palæozoic Rocks.

E. T. Hardman.—On the Discovery of *Diprotodon Australis* in Tropical Western Australia (Kimberley District).

Prof. J. W. Sollas.—On the past and present Bathymetrical Distribution of the *Lithistida.*

C. E. De Rance.—Report on the Circulation of Underground Waters.

Prof. G. A. Lebour.—On the Stratigraphical Position of the Salt Measures of South Durham.

G. H. Morton.—On the Carboniferous Limestones of the North of Flintshire.

Hugh Miller.—On the Classification of the Carboniferous Limestone series—Northumbrian type.

W. A. E. Ussher.—The Culm Measures of Devonshire.

A. R. Hunt.—Denudation and Deposition by the Agency of Waves experimentally considered.

C. E. De Rance and *W. Topley.*—Report on the Erosion of the Sea-Coasts of England and Wales.

Prof. W. I. Macadam and *J. S. Grant-Wilson.*—On Deposits of Diatomite in Skye.

Dr. H. Hicks.—Reports on the Exploration of the Tremeirchion Caves, North Wales.

Prof. T. McK. Hughes.—On the Pleistocene Deposits of the Vale of Clwyd.

Prof. H. Carvill Lewis.—Comparative Studies upon the Glaciation of North America, Great Britain, and Ireland.

Henry Johnson.—On the Extension and Probable Duration of the South Staffordshire Coal Field.

Sir J. W. Dawson.—On the Relations of the Geology of the Arctic and Atlantic Basins.

Dr. G. M. Dawson.—On the Rocky Mountains, with special reference to that part of the Range between the 49th Parallel and the Head-waters of the Red Deer River.

F. D. Adams.—On the Coal-bearing Rocks of Canada.

Prof. T. Rupert Jones.—On the Coal Deposits of South Africa.

Prof. W. Boyd Dawkins.—On the Kerosine Shale of Mount Victoria, New South Wales.

Sir J. Von Haast.—On the Character and Age of the New Zealand Coal Fields.

E. W. Bucke.—On the Geysers of the Rotorua District, N. Island of New Zealand.

Prof. J. W. Judd,—Notes to accompany a Series of Photographs, prepared by *J. Martin, Esq.*, to illustrate the Scene of the recent Volcanic Eruption in New Zealand.

E. T. Hardman.—On the Geology of the newly-discovered Goldfields of Western Australia (Kimberley District).

Richard Meade.—Statistics of the Production and Value of Coal raised within the British Empire.

W. A. E. Ussher.—The Relations of the Middle and Lower Devonian in West Somerset.

W. Whitaker.—Supplementary Note on two Deep Borings in Kent.

Prof. W. Boyd Dawkins.—On the Westward Extension of the Coal-measures in South-Eastern England.

J. S. Gardner.—Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom.

Sir J. W. Dawson.—On Canadian Examples of supposed Fossil Algæ.

Prof. T. McK. Hughes.—On *Bilobites.*

Prof. W. C. Williamson.—On recent Researches amongst the Carboniferous Plants of Halifax.

W. Topley.—Notes on the recent Earthquake in the United States; including a telegraphic despatch from *Major Powell,* Director of the United States Geological Survey.

Prof. John Milne.—Report on the Earthquake and Volcanic Phenomena of Japan.

Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.

Rev. A. Irving.—On the Heat of the Earth as influenced by Conduction and Pressure.

Rev. A. Irving.—A Contribution to the Discussion of Metamorphism in Rocks.

J. Gunn.—On the Influence of the Axial Rotation of the Earth on the Interior of its Crust.

List of Papers bearing upon Geology read in other Sections.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Address by the President, *Prof. G. H. Darwin.*—(Geological Time, etc.)

John Hopkinson.—An Improved Form of Clinometer.

SECTION B.—CHEMICAL SCIENCE.

Dr. H. R. Mill.—Chemistry of Estuary Water.

Dr. O. W. Huntingdon.—The Crystalline Structure of Iron Meteorites.

SECTION D.—BIOLOGY.

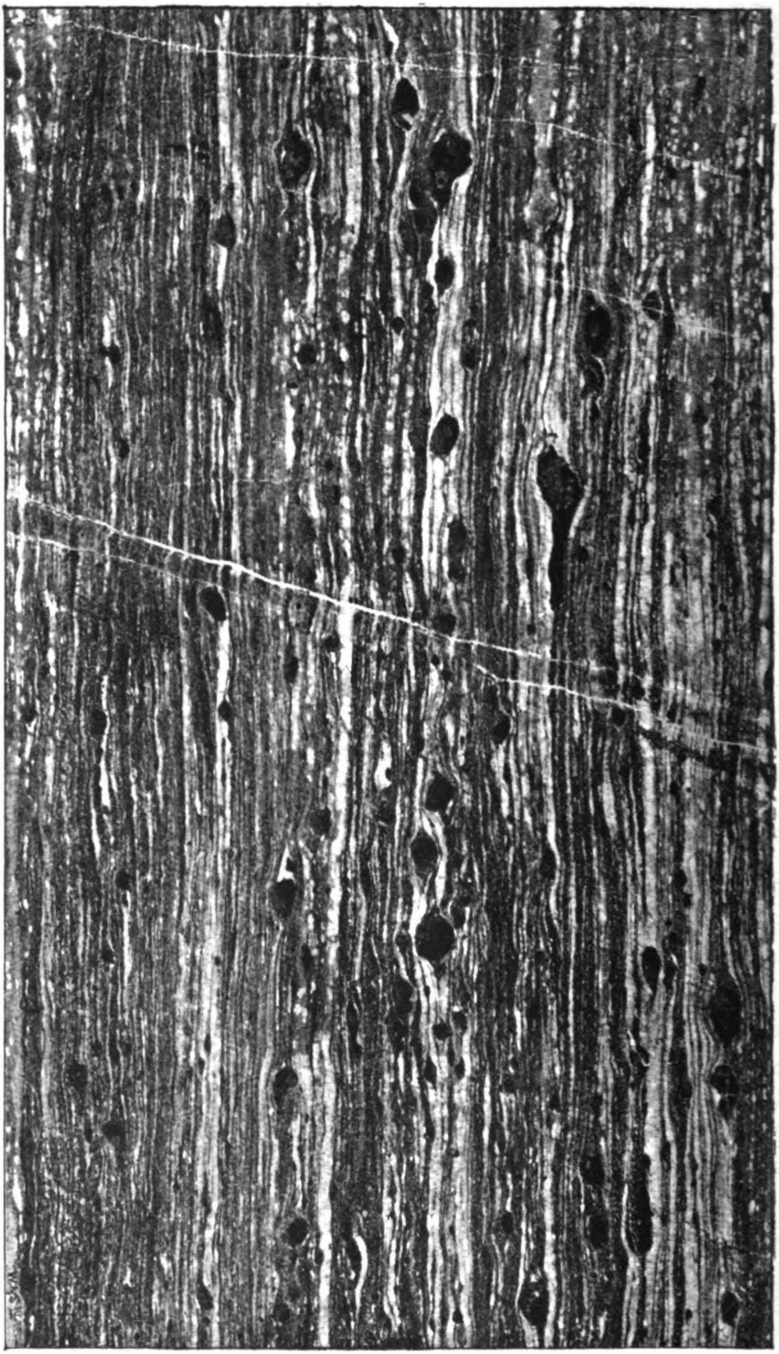
Address by the President, *W. Carruthers.*—(Pliocene Plants, etc.)

SECTION H.—ANTHROPOLOGY.

Dr. Henry Hicks.—On Evidence of Pre-Glacial Man in North Wales.

Prof. W. Boyd Dawkins.—On the Recent Exploration of Gop Cairn and Cave.

Charles N. Bell.—Remains of Pre-historic Man in Manitoba.



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AUGEN-GABBRO (NATURAL SIZE) KARAKCLEWS, LIZARD, CORNWALL.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. XI.—NOVEMBER, 1886.

ORIGINAL ARTICLES.

I.—THE METAMORPHOSIS OF THE LIZARD GABBROS.[1]

By J. J. H. TEALL, M.A., F.G.S.

(PLATE XIII.)

IF we take a general view of the present position of geological science, we are struck by the fact that, although there is substantial agreement amongst geologists on matters relating to the origin of the rocks usually designated as aqueous and igneous, the greatest diversity of opinion prevails with regard to the circumstances under which the so-called metamorphic rocks have been produced. Every fragment of evidence calculated to throw light on the origin of these rocks, therefore, deserves the most careful consideration. Of recent years special attention has been directed to the effects of mechanical energy in modifying the mineralogical and structural characters of rocks originally formed by aqueous and igneous agencies; and a suspicion has been aroused that it is in this direction that we must look for a solution of many of the problems connected with the origin of the crystalline schists. A visit to the Lizard Peninsula of Cornwall during the present summer has convinced me of the immense importance of this view so far as that district is concerned. That portion of the peninsula which lies south of a line drawn from Porthalla on the east to Polurrian Cove on the west is formed partly of igneous rocks—such as gabbro, greenstone, serpentine, and granite—and partly of crystalline schists. The igneous rocks, in certain places, become foliated and schistose and sometimes show a definite banding due to a variation in the relative proportions of the different constituents. In other words they present characters which are usually regarded as distinctive of the crystalline schists. There is, moreover, evidence to show that these characters are mainly the result of a yielding to earth-pressure subsequent to the consolidation of the original rock. At the present moment, having just returned from the district, I am unable to treat the subject from a general point of view with any prospect of success; but it has occurred to me that some details with regard to one of the rocks may not be without interest to members of the Association.

The gabbros of the Lizard have been noticed by many previous writers, including Dr. Boase,[2] Mr. Majendie,[3] Sir Henry de la Beche,[4] and Prof. Bonney.[1] Their mineralogical composition, geographical distribution, and structural characters were described by the older observers. Prof. Bonney added many facts on these points and gave in addition a description of their microscopic structures. As I wish on the present occasion to refer to them for the purpose of establishing a definite proposition with regard to the origin of certain structures which they possess, I must ask permission to recapitulate the facts, and at the same time to add one or two from my own observation.

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[1] Paper communicated to Section C of the British Association.
[2] Trans. Geol. Society of Cornwall, vol. iv. p. 330.
[3] *Ibid.* vol. i. p. 36.
[4] Report on the Geology of Devon and Cornwall, 1839.

Gabbro occupies an area of six or seven square miles in the neighbourhood of St. Keverne, and forms the elevated tract of land known as Crousa Down. This great mass comes down to the sea and forms the coast-line from Coverack to Manacle Point. It is traversed by veins and dykes of a fine-grained rock generally known as "greenstone." This greenstone is essentially composed of plagioclase and hornblende, the latter mineral often belonging to the uralitic and actinolitic varieties. It is, as Prof. Bonney has pointed out, an altered plagioclase-augite rock, and must be classed with the epidiorites (Gümbel) of the Fichtelgebirge and the Hartz. In some instances the felspars give lath-shaped sections which penetrate the fibrous aggregates of secondary hornblende in such a way as to prove conclusively that the parent rock must have been an ophitic dolerite.

The amount of this "greenstone" or "epidiorite" associated with the gabbro increases towards the north until it exceeds that of the latter rock. Although the junctions of the gabbro and the greenstone are perfectly sharp, it is impossible to represent the distribution of the two varieties on a small scale map in consequence of the way in which they alternate with each other. Manacle Point, which is represented as greenstone on the Survey Map, consists for the most part of gabbro in which veins and dykes of greenstone are very common.

The northern limit of the gabbro-greenstone area above referred to occurs in the neighbourhood of Porthoustock. The adjacent rock is hornblende-schist, but the actual junction, which is probably a fault, is concealed by a small shingle beach. The southern limit of this mass comes out on the sea-shore by the small village of Coverack. The geology of this locality has been fully described by Prof. Bonney, to whose paper reference must be made for details. The only point that need be mentioned here is that the normal gabbro is seen to be intrusive in serpentine and also in a rock, intimately associated with the serpentine, which consisted originally of a basic felspar and olivine and which appears to be identical with the troctolite or forellenstein of Neurode in Silesia.

South of Coverack the greater part of the district is occupied by serpentine in which veins and dykes of gabbro frequently occur. The mass of gabbro which ranks next in importance to that of Crousa Down is exposed on the sea-coast west of Lankidden Cove. It forms the headland of Karakclews, and may be followed along the coast for a distance of about a quarter of a mile. A mass of precisely similar gabbro occurs inland at Gwinter. The two portions are doubtless continuous, as represented on the geological map; and if so, they form a dyke-like mass running inland in a N.W. direction. The Karakclews gabbro is bounded on both sides by serpentine into which it was intruded. Marked signs of disturbance occur near both junctions and throughout the mass; but, notwithstanding this, veins of gabbro may occasionally be seen running out from the larger mass into the surrounding rock.

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[1] Quart. Journ. Geol. Soc., vol. xxxiii. 1877, p. 884.

Another considerable exposure of gabbro occurs on the shore north of Pen Voose,[1] near Landewednack. It is bounded on the north by serpentine with gabbro veins, and on the south by a remarkable group of rocks which Prof. Bonney terms "the granulitic series." The gabbro is here traversed by veins of granite and mica-diorite which will doubtless repay careful examination, but which need not be further referred to on the present occasion.

The principal mineralogical constituents of the Lizard gabbros are plagioclase, augite or diallage, hornblende and saussurite. Olivine is present in certain varieties, but does not appear to have been very widely distributed in these rocks. In the least altered rocks the plagioclase occurs in the form of grains of tolerably uniform size and having nearly equal dimensions in the different directions. The grains show broad lamellar twinning, and not seldom two sets of lamellæ are seen crossing each other at right angles. This is the feature which is usually regarded as indicating simultaneous twinning on the albite and pericline types. The extinction angles in thin sections of the rock show that the felspar belongs to the labradorite-anorthite series, but I have not as yet been able to make a more precise determination. In the more or less altered gabbros we see various stages of the replacement of felspar by white or cream-coloured saussurite. The first stage consists in the development of white spots in the glassy felspar substance. These spots appear snow-white under the microscope by reflected light, and opaque or brown by transmitted light. They never exhibit any definite form or cleavages. By the increase in the number and size of these white spots and by other changes the felspar gradually passes into saussurite. This substance sometimes occurs in masses of considerable size, and it is then remarkable for its toughness and hardness. Its specific gravity is about 3·1. Microscopic examination shows that it is an aggregate and not a simple mineral, but it is by no means easy to determine the precise character of the different constituents. Cathrein's[2] investigations led him to the conclusion that saussurite is an aggregate of zoisite or epidote and felspar, usually albite; with variable quantities of actinolite and tremolite as accessory constituents.

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[1] There is some confusion about the naming of this locality. The small bay to the north of which the gabbro is exposed is named the Balk on the one-inch map and Parn Voose on the twenty-five inch map. The inhabitants of this district say that this bay is called Pen Voose and that the place where the life-boat is kept, otherwise known as Church Cove, is Parn Voose. As the maps do not agree, I have followed the inhabitants.

[2] Ueber Saussurit, Zeit. f. Krystallographie, vol. vii. p. 234.

I have not as yet been able to find a saussurite in the Lizard District answering to Cathrein's description.[1]

The felspars of certain gabbros in which the development of saussurite has not taken place at all, or has only occurred to a very limited extent, often give evidence of having been affected by profound mechanical disturbances. The twin lamellæ are frequently bent and, when the limit of elasticity has been exceeded, the crystal grains have been fractured. The extinction is not sharp and definite. Dark shadows sweep across the sections as the stage is rotated. In slides exhibiting these characters large felspars are often seen to break up, in certain places, into aggregates of minute, colourless, and for the most part simple grains. Such aggregates must certainly be regarded as of secondary origin, for they are entirely unknown in the unaltered felspar-diallage gabbros and frequently contain needles of actinolite, a mineral undoubtedly of secondary origin. They correspond to the felspar-mosaic of Lossen.[2]

The pyroxene in the least altered rocks is a pale green diopside. In microscopic sections it is almost colourless. Cross sections show an optic axis in convergent polarized light and frequently the two pinacoidal as well as the two prismatic cleavages. Longitudinal sections give a maximum extinction of about 40°. The mineral is therefore a monoclinic pyroxene. In addition to the cleavages above mentioned, we find occasionally incipient stages of diallagic lamination. This lamination is not as a rule persistent throughout the crystal, but limited to the neighbourhood of cracks. In the ordinary gabbros the pyroxene is a true diallage with a decided bronzy lustre on the planes of easy separation, which planes run parallel with the orthopinacoid. In some of the coarse-grained rocks the diallage crystals often measure two or three inches across.

The change of pyroxene into hornblende has been described and illustrated by Prof. Bonney. It is a common feature in the Lizard gabbros and often accompanies the change of felspar to saussurite. Many different varieties of secondary hornblende may be observed depending on variations in colour and habit. Sometimes the hornblende occurs in the form of homogeneous crystalline grains with strongly marked cleavages. This variety may be termed compact hornblende. At other times the hornblende is distinctly fibrous, and at others it occurs in the form of needles. The two latter varieties are generally termed uralitic and actinolitic respectively. Actinolitic hornblende frequently forms radiating fringes round the uralitic variety or round a crystal of diallage partially changed to uralite. The hornblende may be either green, brown, or colourless. One of the green varieties is remarkably brilliant and of that tint which led to the introduction of the term smaragdite. The gradual replacement of diallage by hornblende is a most striking feature in the Lizard gabbros. The two minerals bear an inverse relation to each other so far as distribution is concerned. As the one increases, the other diminishes.

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[1] A saussurite composed of zoisite and albite occurs in Sangomore Bay near Durness, Sutherlandshire. Under the microscope this is seen to consist of minute colourless prisms embedded in a colourless felspathic matrix. The prisms possess a high refractive index, weak double refraction, cross-jointing at intervals, and give straight extinction. Small fragments of the felspar with which they are associated may occasionally be obtained and when tested in the Bunsen's burner give the flame colouration and fusibility of albite. In the mass this saussurite is white or a very pale pink. It contains hornblende and is associated with a felspathic gabbro in which the diallage has been converted into uralite and actinolite.

[2] Studien an metamorphischen Eruptiv- und Sedimentgesteinen, Jahrbuch d. k. preuss. geol. Landesanstalt für 1883 und 1884.

Olivine does not appear to have been abundant or widely distributed in the normal gabbros. It occurs sparingly in an unaltered rock from Coverack, and in this case is perfectly colourless in thin sections and traversed by irregular cracks, along which magnetite has been formed. In some of the more altered gabbros it is represented by serpentinous pseudomorphs.

The minerals above referred to occur in very different proportions in the different rocks, and in different portions of the same rock-mass. We thus have an endless number of mineralogical varieties. The principal variations are due to the gradual replacement of felspar by saussurite and of diallage by hornblende. The two extreme types may therefore be designated felspar-diallage gabbro, and saussurite-hornblende gabbro; the former representing the original rock and the latter the extreme of mineralogical metamorphism. Between these two extreme types there are innumerable intermediate varieties. As a rule the change in one mineral is accompanied by a change in the other; but this is not invariably the case. We may thus have felspar-hornblende gabbros and saussurite-diallage gabbros. If we wish to indicate the mineralogical character of any intermediate form, we can do so by using a compound term made up of the names of the substances occurring as constituents. The number of actual varieties present is the number of possible combinations of the four principal constituents taken two, three, and four together. The introduction of olivine gives rise to other varieties, but, as already stated, I am inclined to think that this mineral was absent from considerable masses of the original rock.

If we eliminate hornblende and saussurite, both of which are undoubtedly secondary minerals, then the original felspar-bearing rocks of the gabbro-type occurring in the Lizard Peninsula must have comprised plagioclase-augite rocks, plagioclase-augite-olivine rocks, and plagioclase-olivine rocks. By the gradual disappearance of the felspar these rocks passed through the picrites into the peridotites, which are now represented by the serpentines. Felspar-bearing serpentines occur at the Rill Head near Kynance. Looking at the Lizard district as a whole, we are struck with many points of resemblance between it and the Tertiary volcanic district of the West of Scotland described by Prof. Judd.

We have now to consider the structural characteristics of the Lizard gabbros. In the first place, we notice varieties depending on variations in the sizes of the individual constituents. Such variations are characteristic of all masses of gabbro. In the coarsest varieties the individual crystalline grains often measure as much as two or three inches across. These extremely coarse varieties are often distributed with considerable irregularity through large masses of the finer-grained rocks; not seldom, however, they occur as narrow veins and dykes in the serpentine. The dominant gabbro is a rock which would simply be described as coarsely crystalline. Fine-grained varieties are not known. The junction with greenstone or epidiorite is always sharp, and there is no evidence in the Lizard district, so far as I know, of a gradual passage from gabbro into dolerite and basalt. The "greenstones" are undoubtedly altered dolerites, some of which were ophitic, but their junctions with the gabbro are, as already stated, always sharp.

The mutual relations of the individual constituents in the unaltered gabbros are those of typical granitic rocks; in other words, no single mineral appears to have possessed any special advantage over any other so far as the conditions favourable to the development of crystalline form are concerned. Each mineral occurs in the form of crystalline grains.

In addition to variations of structure depending on variations in the sizes of the individual constituents, there are others, of a most important character, dependent on the mode of arrangement of these constituents in the rock-mass. From this point of view the gabbros of the Lizard may be divided into two groups: (1) the massive, and (2) the foliated gabbros. These two varieties are not, however, separated from each other by any hard and fast line. In the massive gabbros the individual constituents are not arranged in any definite manner; in the foliated gabbros a parallel structure is more or less pronounced. It is convenient in speaking of the foliated gabbros to recognize two principal types which may be designated by the terms *flaser-gabbro* and *gabbro-schist*. In the flaser-gabbro the parallel structure, though distinct, is not accompanied by any marked fissility. The constituents are white saussurite and dark aggregates of diallage and hornblende. These constituents are more or less lenticular in form and the flat surfaces of the lenticles lie parallel to each other, thus producing the foliated structure. The gabbro-schist is a rock of finer grain, with a strongly-marked schistosity. It can be broken into flat slabs like a hornblende schist. Indeed the rock may sometimes be called hornblende-schist without doing any violence to the latter term. Although it is convenient to use the expressions flaser-gabbro and gabbro-schist, it must not be supposed that there is any hard and fast line between the rocks designated by these terms. They shade into each other by the most insensible gradations. One very interesting structural variety which is, in some respects, intermediate between flaser-gabbro and gabbro-schist, may be termed augen-gabbro. In this variety the streaks which define the schistosity sweep round "eyes" of diallage, which thus remind one strongly of the "eyes" of felspar in augen-gneiss. (See Plate XIII.)

We have now to consider the distribution of the different structural varieties. The gabbro to the north of Coverack is on the whole massive; nevertheless here and there foliation makes its appearance. In the neighbourhood of the village the veins and dykes of gabbro are often foliated, and every transition may be observed from massive gabbro to gabbro-schist. At Karakclews Headland foliation has been developed in a most striking manner, and affects, with a few local exceptions, the entire mass, which is more than a hundred yards in width. The general strike of the foliation is approximately N.W. and S.E., but there is no absolute constancy in the direction; slight deviations occur sometimes on the one side and sometimes on the other. One important feature in the Karakclews mass is the distinctly banded character of certain portions, particularly those near the southern junction with the serpentine. Light and dark bands several inches in thickness alternate with each other, and with the ordinary flaser- and augen-gabbro, so that the mass as a whole simulates a stratified series. The small dykes of gabbro in the serpentine near Karakclews are often foliated, and not seldom one may see the transition from massive gabbro to gabbro-schist taking place in the space of a few inches.

Another locality where foliation is well developed is north of Pen Voose near Landewednack. The main mass of gabbro is separated from serpentine and other rocks on the north by a well-marked fault-plane. In the immediate neighbourhood of this plane the gabbro is foliated, and passes into a fine gabbro-schist. Foliation also makes its appearance in the main mass, which is here intimately veined with mica-diorite and granite. It is frequently developed near the junction of the gabbro with one of the other rocks. In the small bay known as Pen Voose a lenticular mass of saussurite-hornblende gabbro, measuring about five feet in the longest diameter, occurs in Prof. Bonney's granulitic series. This is evidently not an intrusive tongue, but a lenticular mass which owes its form and position to earth-movements acting after the consolidation of the rock. It is conspicuously foliated parallel with the junction surfaces.

It is instructive to compare the mineralogical with the structural varieties. Foliation is absent from the felspar-diallage rocks. As the foliation becomes more and more pronounced, the diallage is gradually replaced by hornblende, and the felspar undergoes a change resulting for the most part in the development of saussuritic aggregates. In the most perfect gabbro-schist the diallage has entirely or almost entirely disappeared, and its place has been taken by hornblende. It must not, however, be supposed that the mineralogical change is invariably accompanied by the development of foliation. Many of the saussurite-hornblende gabbros are as massive as the original rock. In a paper on the "Metamorphosis of Dolerite into Hornblende-schist" I have pointed out similar relations between structural and mineralogical characters in the case of the Scourie dykes. A molecular rearrangement may take place in a massive rock without the development of foliation; but there is no reason to believe that foliation of the kind referred to in this communication can take place without molecular rearrangement.

The principal question which now remains for consideration is the origin of this foliation. Is it an original or secondary structure? That it is due to a differential movement in the mass after the separation of the individual constituents will I think be admitted on all hands. The only question that can arise is whether this movement was in any way connected with the intrusion of the rock. The facts appear to me to point very decidedly to the conclusion that it is a secondary structure due to earth-movements acting upon the solid rock. That the Lizard district has been profoundly affected by earth-movements is apparent on every hand. The rocks have been folded, faulted, crumpled, twisted, and in some places brecciated by the intense pressures that have acted upon them. The evidences of mechanical disturbance are not limited to any one variety of rock or to any one district. They abound in every portion of the district, though their effects are more pronounced in certain localities than in others. If we attempt to determine the precise nature of the earth-movement, we are met with considerable difficulty on account of the superposition of the effects of distinct movements. The earlier movement, and the one which I suspect produced the greater part of the foliation in the gabbros, appears to have acted so as to produce a strike about N.W. and S.E. or N.N.W. and S.S.E. This earlier movement was, however, certainly followed by one producing faults which run approximately in an E. and W. direction. The latter direction agrees with one of the great post-Carboniferous disturbances, and the faults which run in this direction probably belong to those disturbances. That the two sets of earth-movements above referred to are the only ones that have acted upon the district I am by no means prepared to say; but that these two have acted is shown by facts which may be observed at Porthalla, George Cove and Kynance.

That the foliation in the gabbros is one of the results of the pressure- or regional-metamorphism which has operated upon the district, is rendered at once probable when we compare the Lizard gabbros with those of the West of Scotland. The latter consist mainly of felspar-diallage rocks, and are not foliated; the former are largely composed of saussuritic and hornblendic rocks, and are often conspicuously foliated. The Lizard district has been profoundly affected by earth-movements, whereas the Tertiary volcanic district of the West of Scotland has not been so affected.

This argument is in itself not conclusive, but it becomes greatly strengthened when we consider the distribution of gabbros of the Lizard type. They have been described by Dr. Reusch[1] from the Bergen Peninsula, by Prof. Lehmann[2] from the granulitic region of Saxony, and by Mr. Hatch[3] from the Tyrol. Each one of these districts gives independent evidence of having been subjected to pressure-metamorphism. Perhaps the most convincing proof that the structure is the result of movement after the consolidation of the rock is, however, furnished by its relation to fault-planes. A rock must necessarily be solid before it can be faulted. Now, we find at Pen Voose near Landewednack, that massive gabbro passes over into gabbro-schist at a fault-plane, and that the foliation in the gabbro is such as would be produced by a shearing motion parallel with the fault-plane. Taking all the facts into consideration, we appear to be justified in concluding that the foliation in the Lizard gabbros is the result of pressure- or regional-metamorphism. It seems also probable that the replacement of felspar and diallage by saussurite and hornblende has been largely determined by the same agency.

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[1] Die Fossilien führenden krystallinischen Schiefer von Bergen in Norwegen, Leipzig, 1883.

[2] Die Entstehung der altkrystallinischen Schiefergesteinen, Bonn, 1884, p. 190.

[3] Tsch. Min. Mitth, Band VII. (1885), p. 75.

DESCRIPTION OF PLATE XIII.

The Plate represents the appearance of a polished slab of the augen-gabbro of Karakclews. The "eyes" are formed of diallage. The dark bands are formed mainly of green hornblende; the white bands, of the aggregate generally known as saussurite. The white spots seen in certain parts of the Plate represent an undetermined mineral which is almost constantly present in the Lizard gabbros. It appears in the glassy felspar of the comparatively unaltered rocks, and increases in amount as the felspar passes into the condition of saussurite. There is much greater detail in the dark bands than is represented in the Plate. The block is traversed by narrow veins which cut the planes of foliation at angles of about 15°.

II.—ON THE FFYNON BEUNO CAVES.

By Prof. T. McKENNY HUGHES, M.A., F.G.S.

MUCH interest has been recently aroused in the exploration of the caves of the Vale of Clwyd, partly by the enthusiasm of the principal promoter of the investigation, Dr. Hicks, but chiefly owing to the inferences he has drawn from the observations made. When reading the Report of the British Association Committee for the Exploration, of which he was Secretary, he assumed the entire responsibility of those theoretical deductions. In these, however, he was supported by all the speakers who followed him on the subject, including the other members of the Committee excepting myself. He had previously anticipated the report by the announcement in *Nature* of his discovery of Pre-Glacial Man in the Vale of Clwyd. I therefore ask leave briefly to state my reasons for differing from his conclusions.

First, I recognize in the Vale of Clwyd four drifts which must be distinguished in this inquiry.

1. *The Arenig Drift*, which contains fragments from the W. and S. only, and which is the only true glacial deposit in the Vale of Clwyd, as there is no evidence of any glacier having ever come down the Vale.

2. *The Clwydian Drift.*—(*A*) a marine deposit due to the submergence which followed the age of extreme glaciation and containing, in addition to the re-sorted débris of the older drift, flint and fragments of granite and other north-country rocks. (*B*) the still further winnowed débris belonging to the age of emergence.

I am not very clear about the possibility of often distinguishing between *A* and *B*; but there is a good deal of evidence in some localities.

3. The almost universal covering of re-sorted drifts and rain-wash, the results of subaerial denudation since the submergence.

If the mouth of a cave is said to be blocked by drift, we must be careful to enquire *what drift*, before we take it as a measure of the age of the cave-deposits.

There are some other points also which must be attended to. We must distinguish between the age of the caves and that of the cave-deposits. So many changes and modifications go on in some cases that their history and that of their contents cannot always be read, even during the most careful excavation.

There are in the Vale of Clwyd many caves representing subterranean channels through which the water running off the Silurian hills around, drops into fissures on reaching the Mountain Limestone, and finds its way to lower ground. Some of these caves are being formed now, and in some of them mud still settles after floods. Bones and stones still get washed down into the fissures which feed the cave, and these fissures are often enlarged or new ones opened where the moisture can get access to the rock. So of course the wash from the superficial deposits forms a large item in the later packing of a cave. In the Plas Heaton cave, which I explored with the late Mr. John Heaton, I found pieces of magnums in the cave-earth which were beyond where man could creep when I first knew the cave. The other end of that cave was blocked with clay, full of glaciated boulders: a mass undistinguishable from the clayey Clwydian drift. In the Pontnewydd cave, on the other hand, I found felstone implements and flint flakes not far from the surface near the mouth of the cave.

The limestone on both sides of the little ravine which runs down into the Vale of Clwyd at Ffynon Beuno, near the village of Tremeirchion, is perforated with numerous caves and cavernous places. They very frequently coincide more or less with lines of joint and small faults, along which calc-spar and various minerals suggested the possibility of ore. One precipitous face on the north side had an open cave large enough to furnish a shelter for cattle. In this trial-holes had been dug, and the cave-earth had been moved in places. The fragments of bone lying about suggested that the Sheep and Fox of to-day had once been represented by the Stag and Hyæna, and I suggested to the Chester Natural Science Society to open these caves, and foretold the probability of our obtaining the remains of Primeval Man. The following year Dr. Hicks excavated near the mouth of the cave, and obtained such interesting results, that he obtained a grant from the Royal Society, and afterwards from the British Association, to enable him to carry on the explorations, the results of which he has laid before the Association and other scientific societies. A few feet higher up the rock-face is another opening belonging to the same drainage-system. This also has been excavated by Dr. Hicks and Mr. Luxmoore, and it has been supposed that in it evidence has been obtained of the residence of

Man in that locality before the close of the Glacial period. Now the evidence is briefly this. This cave was filled with a clayey or sandy deposit, containing bones of the extinct Mammalia and boulders of various material. On excavating this deposit, the other or N.W. mouth of the cave was found to be concealed under a deep deposit of sand and sandy clay full of boulders under which, beyond the overhanging ledge of rock, were fragments of bone similar to those occurring in the cave, and, close to the mouth of the cave, a flint flake was found imbedded in red sandy clay, and associated with the teeth of Rhinoceros, etc.

Now what are the points? Was this drift No. 1, or No. 2 *A*, or No. 2 *B*, or No. 3, of our classification given above on p. 489?

Certainly not No. 1, as it contains north country granites, etc., which came into that district for the first time with the submergence. Therefore the drift must belong to No. 2 or 3, and these are Post-Glacial.

We have next to ask whether it is probable that the drift which lies on the bones outside the cave can be the drift laid down in the great Post-Glacial submergence, and the cave-deposits belong to a time anterior to that submergence. Let those accept this view who can imagine that the waves dashing against a precipitous rock exposed to the N.W. winds would not have swept such loose débris into the deep fjord below, and swilled out the cave quite clean in every tide.

I strongly suspect, though I cannot quite prove it, that the mass which overlaps the mouth of the cave belongs to No. 3 drift—I know of no part of the marginal drift at all like it and it differs much from any of that seen in the central portion of the Vale. Neither the beds in the cave nor those outside it look like a shore-deposit.

Again, no notice has been taken of the old fence which runs along the slope up to the precipice, about 20 feet from the entrance to the upper cave, where the flake was found. The soil has accumulated against the upper side of this fence until there is now a drop of eight feet to the level of the ground on the lower side of the fence. This tells of a pretty rapid working down the slope of all the soft surface drift. I think I recognize in some of the stones out of the so-called Glacial drift that blocked the cave the traces of agricultural implements as well as true Glacial striæ. Yet no distinction has been made between a newer superficial remanié drift and an older true Clwydian drift. And rightly so I believe; it is all remanié as far as yet explored.

Next as to the flake. It occurred in a sandy clay such as would be derived from the wash of the Clwydian drift mixed with the unctuous irony residuum of the decomposed limestone, and not in a regular layer or laminated deposit like that found more commonly in the central portion of the cave. It was found in a kind of horizontal fissure after an overhanging corner of limestone had been removed from close above it. Inside of and more especially at the mouth of most caves there is a breccia consisting of angular fragments which have fallen from the rock while the cave was exposed to changes in the amount of moisture and temperature. The interstices get filled with inwashed clay. Sometimes the mouth is blocked by a perfect barricade of large blocks which have fallen from the face of the rock where most exposed. This was very conspicuous at Plas Heaton. At Ffynon Beuno, however, the fragments at the upper entrance were generally small. It was among these that the flake was found.

I do not, however, attach so much importance as some do to the questions connected with the flake. It would be difficult enough to prove that the group of animals found in the Ffynon Beuno caves were Pre-Glacial, for they are the animals commonly found associated with Palæolithic Man, and do not even include what we are accustomed to consider the oldest forms amongst them.

To sum up. Firstly, the deposits of the Ffynon Beuno caves cannot have been formed before the submergence, because rocks first brought into the district during the submergence are found among them. They cannot have been formed during the submergence, because the bone deposits at the mouth would have been washed away, and the deposits inside would have shown some evidence of sea-sorting. So they must belong to an age later than the submergence, and *à fortiori* later than the Glacial age. Secondly, the blocking of the upper entrance seems to have taken place gradually; and while it was going on, drift material was washed into the cave, and various objects got into the crevices of the broken limestone talus; but the lower end of the cave, next the precipice, remained open. Thirdly, the palæontological evidence is against the Pre-Glacial age of the deposit, as the bones belong to the newer group of animals found elsewhere in undoubtedly Post-Glacial river deposits.

III.—ON A FACETTED AND STRIATED PEBBLE FROM THE OLIVE GROUP CONGLOMERATE OF CLIEL HILL IN THE SALT RANGE OF THE PUNJAB, INDIA.[1]

By A. B. WYNNE, F.G.S.

AMONGST others found by Dr. H. K. Warth, the particular pebble referred to was picked up by its discoverer on the 10th of June, 1886, in about lat. 32° 48′ N. and long. 73° 15′ E. Its size is 3¼ inches by 2¼ by 2 inches; and its weight is 10¼ oz. The material is felsitic rock, the colour reddish-brown, and its density = 2·608 (that of albite being 2·59—2·64).

The age of the Olive Group, from which the pebble came, is pre-Tertiary and probably later Secondary, but has even been assumed as Carboniferous, upon what the author believed to be inconclusive evidence.[2]

The pebble itself is smoothed, polished, and striated upon twelve different surfaces. Of these about six are perfectly flat, others less even. On the largest surface the striation is fine, nearly in the direction of the longest axis of the pebble, on other surfaces they cross this direction at various acute angles, ranging from 5° to 25° and upwards.

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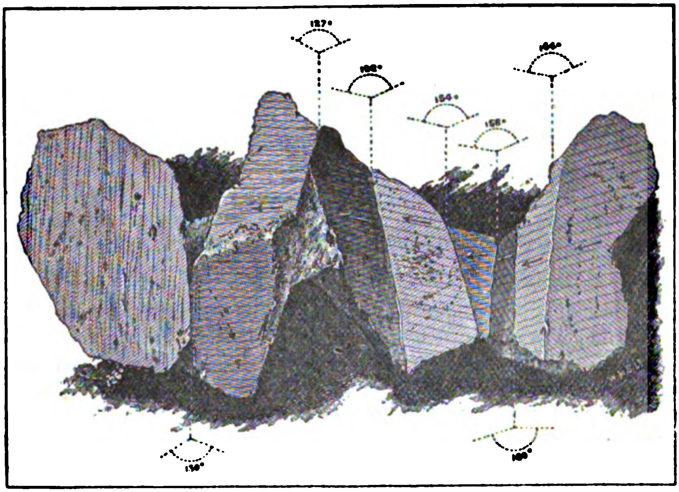
[1] Paper read before the British Association, Birmingham.

[2] See GEOL. MAG. Decade III. Vol. III. p. 232, 1886. The specimen itself is in the Museum of the Department of Science and Art in Dublin, and the enlarged photograph referred to was presented to the Geological Society, London.

An enlarged photograph of the pebble, showing its principal face and the well-marked striation of this, was exhibited. Some of the planes show small cavities, once apparently filled by crystals of pyrites, which, being dislodged and forced, always in similar parallel directions, became the graving-tools by which the stone was scored.

Projection of some of the faces of the pebble, by Prof. O'Reilly, Rl. Col. Sc. Dub.
Reduced to two-thirds nat. size.



In this figure the pebble's principal face is shown to the left, and the others consecutively in contact in one direction as they adjoin each other on the specimen; the figures denoting the angle between each face.

From the position of a group of the facets, all contiguous and of unequal size, together with the slight difference of direction in their striation, it appears that this pebble made about a half revolution nearly around its major axis by six separate stages, being ground and polished at each stage to a degree closely simulating the most artificial accuracy.

The conditions which would permit of this result become a question for consideration. Supposing the pebble to have been grasped by ice, whatever its bulk, having an effective hold of but two inches; this being the utmost amount to which it could have been imbedded while any of these surfaces was exposed: will this account for the sculpture of the specimens?

Other questions which the pebble suggested were:—

1. How it became so frequently shifted in the matrix which produced the resistance that not alone was one-half of it subjected

to grinding processes from different directions, but its exactly opposite side was even more perfectly smoothed and marked than any other?

2. On the supposition that ice was an agent in the case, does the difference in the angles of the faces and the direction of the striation afford a measure of the plasticity of ice?

3. What form of ice agency may have been the originating cause, shore, ground, floe, floating or glacier ice?

4. Was the pebble continuously frozen in or free at times, and was it imbedded in a moving ice mass, or held so as to oppose such a force?

5. Could any other agency than that of ice have produced the result?

These questions were laid before the Section, in order to obtain general and valuable opinions, or elicit suggestions upon a point of great interest, in any case, but particularly, as bearing upon the existence of an earlier glacial period than that so well known to modern geologists; and one which has left its trace in regions where glaciers cannot now possibly exist, though these are found, at a distance, in the higher regions of the Himalayan chain; but even there entirely dissociated from direct connexion with any portion of the Salt Range Geological Series.

IV.—NOTES ON A SMOOTHED AND STRIATED BOULDER FROM A PRE-TERTIARY DEPOSIT IN THE PUNJAB SALT RANGE.[1]

By Dr. W. T. BLANFORD, F.R.S., Sec. Geol. Soc.

THE block of stone in question, like another exhibited by Mr. A. B. Wynne, was obtained by Dr. Warth, at Chel Hill, in the Punjab Salt Range. This specimen was sent by Dr. Warth to Mr. H. B. Medlicott, Director of the Geological Survey of India, who forwarded it to the present writer, in the hope of learning the views of those who have most experience of similarly marked boulders, and of ascertaining whether the peculiar characters of the present specimen are due to any particular form of ice action or to any other agency.

The stone consists of a purplish-brown porphyry, apparently an altered felspar-porphyry. This rock is known to occur in Rajputana, near Jodhpur, between 300 and 400 miles south of the Salt Range, and belongs to a group of beds supposed to be Archæan, and known by the name of Maláni. These rocks may occur nearer to the Salt Range, but the intervening country is imperfectly known, and is much covered with river alluvium and blown sand.

The boulder exhibited measures 7½″ × 6″ × 3½″. It is subangular, the two principal surfaces are plane, smooth, finely striated, opposite to each other, and nearly but not quite parallel. Each of these surfaces is bevelled off on one edge by a number of smaller facets, meeting the principal surface and each other at very obtuse angles. Besides the larger plane surface there are on one side five smaller smoothed facets, and on the other two, but one in each case is ill-marked, the angle at which it meets the next surface being so obtuse as to be with difficulty recognized. All the smoothed surfaces on one side are striated in the same direction; those on the other side are striated similarly to each other, but diversely to those on the opposite surface of the block. Those surfaces of the block that are not smoothed are somewhat rounded.

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[1] A paper read before the British Association, Birmingham.

The bed from which the block was obtained is said to abound in similar boulders, but they are not in general smoothed or striated. They are found in an olive-coloured matrix of fine silt. The bed has been described by Mr. Wynne, Dr. Waagen, and Mr. R. Oldham, and a general *résumé* of its geological relations was given in the Quart. Journ. Geol. Soc. for the present year, p. 254. The strata immediately overlying are marine, and contain fossils that are either Palæocene or very high Cretaceous, but the age of the boulder bed itself is somewhat doubtful. The occurrence of large boulders in a fine silt appears to indicate glacial conditions as in the Talchir beds of India, of which there is a possibility that this Salt Range bed may be a representative, although most of those who have examined the ground think it to belong to a much later geological period, and associate it with the overlying Upper Cretaceous or Palæocene strata.

V.—On Fossil Flowering or Phanerogamous Plants.

By J. S. Gardner, F.L.S., F.G.S.[1]

Our attention has been devoted exclusively this year to the fossil flowering or phanerogamous plants. The results of our researches point to the conclusion that while that section known as Gymnospermous, to which the Coniferæ belong, is of the highest antiquity, being almost coeval with the first definite remains of plants in the Palæozoic age, there are no Angiospermous plants in British rocks of greater antiquity than the Secondary period, if we except the problematic plant known as *Spirangium*. Even down to so late as the Lias we have been unable to ascertain that any indisputable Angiosperm has been discovered within our area, for we are led to the conclusion that the supposed Monocotyledons from the Rhætics, near Bristol, hitherto referred to the family of Pond-weeds under the name *Najadita*, are really cryptogamic plants of the moss tribe, closely allied to the river moss *Fontinalis*. This group had not previously been found fossil, and, so far as it goes, would indicate rather a temperate climate. It is important to notice that these conclusions are shared by such high authorities on fossil plants as Prof. Williamson, Mr. Carruthers, and by all botanists who have examined them, as well as Mr. Brodie, the possessor of the specimens. The *Lilia*, *Bensonia*, and other supposed Monocotyledons of similar age are very imperfectly preserved and, doubtless referable to Cycads, a family which abounded then.

We have examined a large number of specimens of the anomalous Jurassic plant described by Carruthers as *Williamsonia*. It is well known that Prof. Williamson, in whose possession or charge a number of the finest specimens remain, has devoted a considerable amount of attention to them, without, however, feeling justified in coming to any very definite conclusion as to their true position in the vegetable world. De Saporta, on the other hand, has found more perfectly preserved specimens in France, and has no hesitation whatever in referring them to the group of *Pandanaceæ.* Though there are still many difficulties in the way, our own examination of the specimens in London, Manchester, Cambridge, and elsewhere, tends to confirm Saporta's view so far as that there do appear to be vestiges, in some cases at least, of lignitic structure which may represent the areolæ or carpels. These rather minute cavities and the lignitic matter surrounding them fall away on exposure to the air, and only traces of them are visible. Should Saporta's contention be upheld, *Williamsonia* will be by far the most perfectly known of the Secondary Angiosperms, since all the organs of fructification and even of foliation are more or less known.

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[1] Being the Second Report of the Committee, consisting of Mr. W. T. Blanford, Professor J. W. Judd, and Messrs. W. Carruthers, H. Woodward, and J. S. Gardner (Secretary), appointed by the British Association for the purpose of reporting on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom.

A still more definite Monocotyledon is the *Podocarya,* from the Inferior Oolite, originally figured by Buckland, and redescribed by Carruthers. Its resemblance to the fruit of *Williamsonia,* as interpreted by Saporta, is extremely striking, and on suggesting this to that author, he replied that he was in the act of preparing an important work on the very subject. The same work is to include an illustration of the most recent member of the group, obtained from the Grey Chalk of Dover, and which we thought advisable to communicate to him.

Next in point of age, among English Monocotyledons, to the *Podocarya* is the *Kaidacarpum,* from the Great Oolite, also described by Carruthers, and by him referred to the *Pandaneæ.* We have been able to ascertain that a second species, hitherto supposed to be of Cretaceous age, from the Potton Sands, is a derived fossil, and undoubtedly Jurassic. A third species was originally figured, without any reference in the letterpress as to its age or locality, by Lindley and Hutton as *Strobilites Bucklandi,* in their 'Fossil Flora,' vol. ii. p. 129, published between 1833–35, from a drawing made by Miss E. Benett for Dr. Buckland. In the first edition of Morris's 'Catalogue,' 1843, it is set down as from 'Gr. S. Wilts,' which cannot mean either Lower or Upper Greensand, the abbreviations for which are 'L. G. S.' and 'U. G. S.,' but which certainly looks like a misprint for 'Gr. O.,' the sign for Great Oolite. In the second edition of Morris, 1854, the locality is corrected to 'U. G. S. Wiltshire,' but it appears likely that the correction may have been made without ascertaining the facts *de novo,* for the only entry occurring in Miss Benett's 'Catalogue of the Organic Remains of Wiltshire,' published in 1831, that could possibly refer to this fossil, is a '*Cycadeoidea?*' from the Portland Beds, which occurs under the heading 'Woods' on p. 9. A journey to Newcastle with the object of examining the Hutton collection of fossil plants, where it seemed probable the specimen might be found, has been unsuccessful, and its present whereabouts is still unknown. We think, it however, far more likely to prove a Jurassic than a Cretaceous fossil if found, and the genus should not be included in lists of plants of the latter age.

The oldest Monocotyledons thus appear to be referable to the Pandaneæ, a group of plants distributed in widely distant and remote oceanic islands, whose fruits are still met with at sea in drifts of vegetable matter.

Next to these in antiquity are two very monocotyledonous-looking fragments from the Jurassic of Yorkshire, which have been fully described in the Geological Magazine for May and August. The one is apparently an unopened palm-like spathe, and the other a jointed cane-like stem. Mr. Brodie possesses an undoubtedly monocotyledonous leaf fragment from the Purbeck of Swindon.

The *Aroïdeæ* have long been supposed to be a group of very high antiquity, but there are good reasons for believing that the supposed remains of aroïdeous plants from beneath the Tertiaries are, without exception, referable to other groups, and actually there are no known traces of them earlier than the Middle Eocene, when they become by no means uncommon.

In a similar manner the fruits once supposed to represent *palms* in the Palæozoic and Mesozoic rocks have been gradually removed or suppressed, and, unless the fragments of palm-like wood in the Gault at Folkestone are taken into account, there are no traces of palms in any of our Secondary strata. They, however, appear as low down in our Eocene as the Woolwich series.

We are not able to speak with certainty regarding the supposed liliaceous or *Dracæna*-like stems from the Wealden, so frequently mentioned by Mantell, since it is not easy now to identify the particular specimens referred to by him; but it is very probable that certain stems of *Endogenites* in the British Museum are those intended, in which case they are, of course, cycadeous. The Wealden has, indeed, so far yielded no trace whatever of any more highly organized plants than ferns and Gymnosperms, and this, when we consider that Monocotyledons were undoubtedly in existence, is a fact that should be of great significance to speculative geologists. The sediments must represent the deposits of the drainage system of a large area, for they are of vast extent and thickness, varied in character, and abounding in remains of trunks and stems, fruits and foliage of plants. In them, therefore, if anywhere, we might reasonably expect to find at least the traces of reed and rush, but the swamps seem to have been tenanted only by Equisetum and ferns, and the forests by Cycads and Conifers.

The same absence of Angiosperms, so far as British rocks are concerned, is continuous throughout the Neocomian and Gault, and it is only in the White Chalk that we meet with any indications of them, and these only take the form of a more than suspicious impression of a net-veined leaf, in the Jermyn Street Museum, and of some structureless bodies which were apparently some kind of fruit.

When, however, we turn to the gymnospermous section of Phanerogams, the records are very different. To refer here to the earlier Secondary Coniferæ and Cycadeæ would be quite beyond our province, and it is only those of the Cretaceous, as the last discoverable ancestors in our area of the Eocene flora, that are of immediate interest. These belong, excluding Cycads, chiefly to the newest section of the Coniferæ, the Pine family. We are able to make the following contribution to our knowledge of these:

Pinites Andræi, Coemans. 'Flore fossile du Terrain Crétacé du Hainault,' 1866, p. 13, pl. v. fig. 1. Gault, Folkestone.

This specimen measures 5 centimetres in length and nearly 3c. in breadth, though something should be perhaps deducted for the compression undergone. When perfect, it was probably composed of 50 to 60 imbricated leathery scales, about half that number being visible on the exposed face. The substance of the scale seems to have been considerable, though the edges are thin; they are smooth even without striæ, and with the upper margin round to obtusely pointed. They are apparently variable in size.

The cone is of the same general type as *P. Andræi*, Coem., from the Gault of La Louvière, Hainault, though somewhat shorter, more oval, and with thinner and rounder scales. The form and general consistence of the scales, as well as their size, the number composing each whorl, and their disposition are, however, so similar that we think it better, in the case of so imperfect a specimen, to unite it rather than claim specific rank on account of distinctions that might largely disappear with more perfect specimens. If the assimilation is correct, the apex of the cone, as well as the base, would have been somewhat pointed. The cones are most abundant at La Louvière, more than 100 specimens having been collected; and they are stated to have been frequently curved and highly resinous. The specimen from Folkestone was found by us, being unique from that locality, and is now in the British Museum.

Pinites Valdensis, sp. nov., Wealden, Brook Point, Isle of Wight.

This fragment shows the presence in the Wealden flora of a Pine of the section *Strobus* with a cone composed of scales as numerous and thin as in any recent species. The cone was long, cylindrical, and tapering; the scales very numerous, permanent, imbricated, leathery, pointed, and lightly thickened at the apex, with entire margin, striated, and slightly keeled. It somewhat resembles *P. Dunkeri*, Carr., also of the Wealden, but is probably a distinct species. One specimen is in the York Museum, and another, in which all the scales are mutilated, is in the Woodwardian Museum. Both these, with several others, are from the Wealden of Brook, so that it appears to be by no means rare there. It is associated with *Cycadostrobus elegans*, Carr.[1]

Pinites Carruthersi, sp. nov. Wealden, Brook Point, Isle of Wight.

The fragment represents another long cylindrical cone with very numerous persistent leathery imbricated scales. It tapers like the one last described towards the base, the scales being much thicker, though thin at the edge, smooth, without keel, and with entire rounded margins. It resembles the Gault species *P. Andræi* in texture, but there were at least twice as many scales in each whorl, and these are much more imbricated. It also is quite distinct from *P. Dunkeri*, Carr.

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[1] *Journ. of Bot.* vol. iv. pl. lvii. fig. 9.

It resembles *Cedrus Lennieri*, 'Sap. Veg. foss. de la Craie inférieure des Environs du Hâvre,' *Mém. de la Soc. Géol. de Normandie*, 1877, but is not apparently the same species.

Pinites cylindroides, sp. nov., Lower Greensand, Potton.

This is an almost perfectly cylindrical specimen, being very slightly thickened towards the base, 7 centimetres in length and 22 millim. in diameter, composed of about 96 scales, arranged in 12 rows from left to right, and eight rows from right to left, the arrangement thus being $\frac{8}{12}$. The scales are short and at right angles to the axis, with a smooth flat half-moon-shaped apophysis or scale-head, now gaping, but evidently imbricated before the seeds were shed. The scales become very small towards the base. The summit is abraded, exposing the end of a somewhat slender axis. Certain grooved lines on the sandy matrix between the scales show that the cone was furnished with foliaceous bracts, and the marks of a boring insect are visible. The specimen, which is quite distinct from any other fossil or recent cone, is singularly elongated and cylindrical, scarcely tapering at all from the base upward. It is fortunately in excellent condition, certainly not derived from any older bed, like so many of the Potton fossils, and is well cared for in the Woodwardian Museum.

Pinites Pottoniensis, sp. nov., Lower Greensand, Potton.

The fragment, though much mutilated, fortunately shows the characteristically winged seeds of *Pinus* in the most perfect manner, entirely removing any lingering doubt as to the occurrence of representatives of true *Pinus* as low down as the Neocomian. The scales were set at an acute angle with slightly thickened recurved apophyses, the form of which cannot clearly be made out, though they appear to have been narrow, keeled, and mucronate. It nearly resembles a type very common in the Eocene, and is of great interest in many ways. It also is in the Woodwardian Museum, and was obtained from the same formation.

Another specimen evidently represents a third species from the Wealden of Brook, with scales very closely resembling a common Barton and Bracklesham type, but its fragmentary condition scarcely renders it advisable to attach any specific name to it.

The accompanying list comprises all the British Cretaceous Coniferæ previously known up to the present date, though there is no doubt that many new and undescribed forms exist in collections.

List of British Cretaceous Coniferæ previously described.

Pinites Fittoni, Carr., Purbeck, Fitton, Geol. Trans. 2nd series, vol. iv. p. 230, pl. xxii. fig. 9. Dammarites, Ung. G. et Spec. Plant. foss. p. 384. Geol. Mag. Vol. III. p. 543.

P. Mantellii, Carr., Geol. I. of W. 2nd ed. p. 452, 3rd ed. p. 377, pl. xlii. ; and Carr. Gym. Fruits, Geol. Mag. Vol. III. p. 543, Pl. XXI. Fig. 3, Tilgate.

P. patens, Carr. id. p. 543, Pl. XXI. Fig. 4, Tilgate.

P. Dunkeri, Carr. id. p. 542, Pl. XXI. Fig. 1-2, Brook. Abietites, Mant. Geol. I. of Wight, 2nd ed. p. 452.

P. Sussexiensis, Carr. Zamia, Mant. Quart. Journ. Geol. Soc. vol. ii. p. 51, pl. 2, fig. 1 ; Zamites, Morris Cat. Zamiostrobus, Goepp. Ueber Schless. Gesellsch. 1844, p. 129 ; Pinites, Carr. Geol. Mag. Vol. III. p 541, Pl. XX. Figs. 5, 6.

Cedrus Leckenbyi, Carr. Pinites, Geol. Mag. Vol. VI. p. 2, Pl. I. Fig. 1-5, Shanklin.

P. elongatus, Endl. Synops. Conif. p. 286; Strobilites, Lind. and Hutt. Foss. Flora, vol. ii. p. 23, pl. 29.

C. Benstedi, Carr. Abies, Mant. Quart. Journ. Geol. Soc. vol. ii. p. 51, pl. ii. fig. 2, 1846. Pinites, Carr. Journ. Bot. Jan. 1867; Geol. Mag. Vol. III. p. 541; Abietites, Goepp. Foss. Conif. p. 217.

Abies oblonga, Lind. and Hutt. vol. ii. p. 155, pl. cxxxvii. Supposed to be from Greensand, near Lyme Regis; described by a misprint as from 'Dresent,' instead of 'present' shore. Elate, Unger, Syn. p. 199. Abietites, Goepp. Foss. Conif. p. 207. Pinites, Endl. Synops. Conif. p. 248; Carr. Geol. Mag. Vol. III. p. 541. (Professor Williamson is describing a magnificent specimen of this or an allied form).

Pinites gracilis, Carr. Gault, Folkestone, Geol. Mag. Vol. VI. p. 2, Pl. I. Fig. 9.

P. hexagonus, Carr. id.[1] Vol. VIII. p. 540, pl. XV.

Sequoiites Gardneri, Carr. id. Vol. VI. p. 2, Pl. I.

Sequoiites ovalis, Carr. id. Vol. VIII.

Sequoiites Woodwardii, Carr. Geol. Mag. Vol. III. p. 544, Pl. XXI. Fig. 11–16, Blackdown.

We have now dealt with the more highly-organized of our Mesozoic plants, and pass on to those of the Eocene.

Among the most interesting of recent discoveries is that of plant remains in a small sand-pit at Colden Common, between Bishopstoke and Winchester, the first locality in the Hampshire basin that has yielded any of Woolwich and Reading age. This was first communicated to us by Mr. Whitaker, who thought the leaves might prove to be of London Clay age. They are, in fact, actually included in its basement bed, and mingled with casts of marine shells and sharks' teeth, but the blocks of clay with leaves are derived, though other unfossiliferous clay-seams are *in situ*. If not of London Clay age, however, they are much nearer to it than the Reading flora, which occurs below the great mass of mottled clay, whilst these lie above it. The plants show in the main, as might be anticipated, an approach to the Alum Bay flora, which is still higher and above the London Clay; but whether these leaves are connected in any closer degree with the fruits of Sheppey than are those from Woolwich, Croydon, or Bromley, is a question which we have not as yet the data for answering. There are, at all events, no remains of Palms among them, and this, so far as it goes, is against the connection; but on the other hand the fruits of an *Alnus*, like that from Swale Cliff, abound. There is no large variety among the leaves, the majority being large and simple, but with highly serrate margins, and the species will not be found to exceed 12 or 14 in number, including *Platanus*, which is rare.

Though we have continued to collect at Reading, we have been unable so far to determine any new species. The assemblage of fruits at Sheppey, on the other hand, becomes of increasing interest, and has proved unexpectedly rich in Palms, many of them apparently identical with existing species which are now found growing in the remotest regions.

Besides the large variety of Nipas, which are still met with in enormous abundance among the seed-vessels of the New Guinea drift, we have seeds indistinguishable from *Verschaffeltia splendida*, endemic to the Seychelles, from *Sabal Blackburniana* of the Bermudas, from a *Desmoncus*, an *Areca*, a *Monodora*, and probably of many, certainly of some other palms. When we consider that probably many of the kinds of palm fruits would sink at once, we realize how great an assemblage of this magnificent family is indicated by the Sheppey drift.

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[1] A far larger specimen than that originally described, 8 inches long by 1¼ inches in diameter, has since been found.

The difficulties we fear of determining anything but a fraction of the Sheppey fruits must prove insurmountable. Their outer coats are for the most part destroyed, and some part of their inner structure, nearly always quite different in form from that which is external, is revealed. Botanists have been able to determine but few of the drifted fruits brought home by the *Challenger*, though these are more perfect and of living species belonging to definite and known floras.

The Bournemouth cliffs continue to furnish fresh forms, though the leaf-beds are becoming more and more difficult of access. We have especially enriched the series of *Smilaceæ*, and a complete account of them has been presented to the Linnean Society. The series now obtained falls little short of a hundred specimens, and is by far the richest of fossil Smilaceæ, perhaps of any family, ever brought together. Such a material has enabled us to reduce the number of distinct species to no more than five, most of which are represented by foliage in all stages of development, from the largest leaves measuring several inches, down to quite minute leaves from near the extreme growing points. The necessity for such extensive series when dealing with fossil leaves may not at once be apparent, but the President of the Linnean Society expressed the opinion at the meeting, that out of less material, not five, but five-and-twenty species might have been made.

The leaves of Smilaceæ are highly characteristic, and can be determined with a large degree of certainty; but it is quite improbable that such will be the case with very many of the families of Dicotyledons. There is, indeed, little hope that more than a very few can be determined with anything like the precision required for botanical purposes, unless we can call in aid the fruits or some other organs. Thus if we may base a conclusion upon the large number of the characteristic bracts, which envelope the seed in a section of *Flemingia* that are met with in the Bournemouth flora, the leaves of that genus should be far from uncommon, and they should also be found in the Swiss Oligocene, yet no species of *Flemingia* has ever been recorded from the Tertiaries. The leaves, however, may be sought for among the supposed species of *Populus* and *Carpinus*.

Fortunately fruits and even flowers are comparatively abundant at Bournemouth, and we consequently anticipate little difficulty in determining leaves belonging to such easily distinguishable fruits as *Alnus, Tilia, Acer, Carpinus*, the *Leguminosæ*, and many others, but the residuum with indeterminable fruits, or fruits that will not float, may be very large. We are thus brought to the question, whether any value beyond that of mere landmarks, or aids to the correlation of rocks, can be attached to the determinations of fossil dicotyledonous leaves arrived at when fruits are absent. Nearly every Tertiary and even many Cretaceous floras are said to comprise *Quercus*, and *Fagus*, and *Corylus*, to select these as typical examples. Now we very much doubt whether the fruits of these genera have been met with in any strata older than the Upper Miocene, we might almost say the Pliocene; whilst in the latter the fruits of at least two of them are very far from uncommon. Fossil hazel-nuts are well known to abound in forest beds such as the one at Brook, in the Isle of Wight, and at Carrickfergus. It does appear to us that it would have been wiser and more consistent, when arriving at these determinations, to have taken the absence of fruits into account, when these were such as would naturally have been preserved. The large proportion of fossil dicotyledonous leaves that have been referred without any hesitation to living genera must strike every one, in comparison with the relatively few associated fruits that have been determined otherwise than as Carpolithes—a name which is a confession of failure. It will thus be seen that in our opinion the fossil Dicotyledons of our own Eocene must be dealt with in a manner different from that pursued by the majority of foreign writers on kindred subjects, and that a revision of much of their work is urgently needed.

To resume our immediate subject, we have nothing new to record of the Bracklesham flora except that Mr. Elwes, in excavating in the New Forest, met with Nipadites in some abundance, and a specimen he still has proves the species to be the same as that from Bracklesham Bay, and entirely different from that which forms a conspicuous zone in the marine series of the Bournemouth group.

At Barton, on the other hand, we have been able to procure nearly a dozen pine-cones, hitherto a great desideratum, from the Highcliff beds, which go far to prove that there is only one variety there, indistinguishable from the *Pinus Dixoni* of Bracklesham. Along with these we have branches of apparently the Bournemouth *Araucaria*, and an important and entirely new fruit, fortunately represented by many specimens, which permit us to examine the details of their structure. These consist of twigs on which are seated in some profusion clusters of numerous sessile woody pericarps with deeply laciniate margin, giving the fruit when closed the appearance of a large burr. These inclose a nut or seed, rather smaller, but otherwise resembling that of a cucumber. There has not yet been time to make the researches necessary to come to a conclusion regarding it, and Mr. Carruthers and other botanists who have seen the specimens are unable offhand to pronounce upon its affinities. A rather large fossil plant from the same locality has recently been lent us by the Council of the Hartley Institute, and altogether the plants from this horizon, hitherto very meagrely represented, bid fair to take an important position. On the other hand, the Hordwell end of the same section, though twice visited since our last report, has furnished nothing new.

We have fortunately met with a few very distinctly marked leaves from the Middle Headon of Headon Hill, preserved in the York Museum, which with those previously obtained from the Lower Headon of Hordwell, help to bridge-over one of the few gaps in our really surprisingly complete succession of Eocene floras.

We have continued to investigate the great series of plant remains so assiduously collected by Mr. A'Court Smith, and with this object have visited Gurnet Bay, as well as receiving several packages of fossils from thence. While lamenting that they are of so fragmentary a nature, we cannot overlook their importance as almost the last representatives of the great series of floras which maintained themselves in our area throughout the Eocene time. As an illustration of their value, we may instance the fact that while anything like true grasses seem to be wholly wanting in the previous floras, there are many more or less definite indications of them in this. We have reason to hope that renewed working in the still younger beds of Hempstead may lead to further discoveries, for, besides the better known plants described by Heer, pine-cones and a fine aroïdeous fruit have been obtained from them.

NOTICES OF MEMOIRS.

Papers read before the British Association for the Advancement of Science, Birmingham, September, 1886, Section C (Geology).

I.—On Canadian Examples of Supposed Fossil Algæ. By Sir William Dawson, LL.D., F.R.S.

MARKINGS of various kinds on the surfaces of stratified rocks have been loosely referred to Algæ or Fucoids under a great variety of names; and when recently the attempt was made in Europe more critically to define and classify these objects, a great divergence of opinion developed itself, of which the recent memoirs of Nathorst, Williamson, Saporta, and Delgado may be taken as examples.

The author, acting on a suggestion of Sir R. Owen, was enabled in 1862 and 1864, by the study of the footprints of the recent *Limulus polyphemus*, to show that not merely the impressions known as *Protichnites* and *Climactichnites*, but also the supposed fucoids of the genera *Rusophycus*, *Arthrophycus*, and *Cruziana* are really tracks of Crustacea, and not improbably of Trilobites and Limuloids.[1] He had subsequently applied similar explanations to a variety of other impressions found on Palæozoic rocks.[2] The object of the present paper was to illustrate by a number of additional examples the same conclusions, and especially to support the recent results of Nathorst and Williamson.

Rusichnites, *Arthrichnites*, *Chrossochorda*, and *Cruziana*, with other forms of so-called *Bilobites*, are closely allied to each other, and are explicable by reference to the impressions left by the swimming and walking feet of Limulus, and by the burrows of that animal. They pass into Protichnites by such forms as the *P. Davisii* of Williamson, and *Saerichnites* of Billings, and *Diplichnites* of the author. They are connected with the worm tracks of the genus *Nereites* by specimens of *Arthrichnites*, in which the central furrow becomes obsolete, and by the genus *Gyrichnites* of Whiteaves.[3]

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[1] "On Footprints of Limulus," Canad. Nat. 1862. "On the Fossils of the Genus *Rusophycus*," *Ibid.* 1864.

[2] "On Footprints and Impressions of Aquatic Animals," Am. Journ. of Science.

[3] Trans. Royal Society of Canada, 1883.

The tuberculated impressions known as *Phymatoderma* and *Caulerpites* may, as Zeiller has shown, be made by the burrowing of the mole-cricket, and fine examples occurring in the Clinton formation of Canada are probably the work of Crustacea. It is probable, however, that some of the later forms referred to these genera are really Algæ related to *Caulerpa*, or even branches of Conifers of the genus *Brachyphyllum*.

Nereites and *Planulites* are tracks and burrows of worms, with or without marks of setæ, and some of the markings referred to *Palæochorda*, *Palæophycus*, and *Scolithus* have their places here. Many examples highly illustrative of the manner of formation of these impressions are afforded by Canadian rocks.

Branching forms referred to *Licrophycus* of Billings, and some of those referred to *Buthotrephis*, Hall, as well as radiating markings referable to *Scotolithus*, *Gyrophyllites*, and *Asterophycus*, are explained by the branching burrows of worms illustrated by Nathorst and the author. *Astropolithon*, of the Canadian Cambrian, seems to be something organic, but of what nature is uncertain.

Rhabdichnites and *Eophyton* belong to impressions explicable by the trails of drifting seaweeds, the tail-markings of Crustacea, and the ruts ploughed by bivalve molluscs.

Dendrophycus, *Dictyolites*, some species of *Delesserites*, *Aristophycus*, and other branching and frond-like forms, were shown to be referable to rill-marks, of which many fine forms occurs in the Carboniferous of Nova Scotia, and also on the recent mud-flats of the Bay of Fundy.

The genus *Spirophyton*, properly so called, is certainly of vegetable origin, but many markings of water action, fin-marks, etc., have been confounded with these so-called 'Cauda-galli fucoids.'

On the other hand, some species of *Palæophycus*, *Buthotrephis* and *Sphenothallus* were shown to be true Algæ, by their forms and the evidence of organic matter, and *Haliserites*, *Barrandeina*, and *Nematophycus* were shown to include plants of much higher organization than the Algæ. With reference to the latter, it was held that the form to which the name *Prototaxites* had been given was really a land plant growing on the borders of the sea, and producing seeds fitted for flotation. On the other hand, certain forms to which he had given the name *Nematoxylon* were allied to Algæ in their structure, and may have been of aquatic habit; very perfectly preserved specimens of these last had been recently found, and had thrown new light on their structure.

The author proposed to apply to all these problematical plants, having a tissue of vertical and horizontal tubes, the general name *Nematophyteæ* or *Nematophyton*.

The paper referred to the history of opinion on these objects and the bibliography of the subject; but this, as well as detailed descriptions, are omitted in this abstract.

II.—On the Relations of the Geology of the Arctic and Atlantic Basins. By Sir J. William Dawson, LL.D., F.R.S.

THE paper relates to the evidence of the specimens brought from the Arctic seas bearing on the existence of an ancient line of Laurentian Huronian, and other Pre-Cambrian rocks; of the extension of the marine fauna of the Atlantic and the American continental plateau into the Arctic, and of the correspondences of the Cretaceous, Tertiary, and Pleistocene of the Arctic Basin with those of America, and the bearing of these facts on questions of palæogeography.

III.—ON THE ROCKY MOUNTAINS, WITH SPECIAL REFERENCE TO THAT PART OF THE RANGE BETWEEN THE 49TH PARALLEL AND HEAD-WATERS OF THE RED DEER RIVER.

By GEORGE M. DAWSON, D.Sc., F.G.S., etc., Assistant-Director, Geological Survey of Canada.

THE term "Rocky Mountains" is frequently applied in a loose way to the whole mountainous belt which borders the west side of the North American continent. This mountainous belt, is, however, preferably called the Cordillera region, and includes a great number of mountain systems or ranges, which on the 40th parallel have a breadth of not less than 700 miles. Nearly coincident with the 49th parallel, however, a change in the general character of the Cordillera region occurs. It becomes comparatively strict and narrow, and runs to the 56th parallel or beyond with an average width of about 400 miles only. This portion of the western mountain region comprises the greater part of the province of British Columbia. It consists of four main ranges, or, more correctly, systems of mountains, each including a number of component ranges. These mountain systems are, from east to west:—(1) The Rocky Mountains proper. (2) Mountains which may be classed together as the Gold Ranges. (3) The system of the Coast Ranges of British Columbia, sometimes improperly named the Cascade Ranges. (4) A mountain system which in its unsubmerged portions constitutes Vancouver and the Queen Charlotte Islands.

The present paper refers to the Rocky Mountains proper. This system, between the 49th and 53rd parallels, has an average width of about 60 miles, which, in the vicinity of the Peace River, on the 56th parallel, decreases to about 40 miles. It is bounded to the east by the Great Plains, which break into a series of foot-hills along its base; to the west by a remarkably straight and definite valley occupied by portions of the Columbia, Kootanie and other rivers.

Since the early part of the century the trade of the fur companies has traversed this range, chiefly by the Athabasca and Peace River Passes, but till the explorations effected by the expedition under Capt. Palliser in 1858-59 nothing was known in detail of the structure of the range. At the inception of explorations for the Canadian Pacific Railway, Palliser's map was still the only one on which any reliance could be placed, and it applied merely to the portion of the range south of the Athabasca Pass. During the progress of the railway explorations a number of passes were examined, and in 1883 and 1884 that part of the range between the 49th parallel and latitude 51° 30″ was explored and mapped in some detail in connection with the work of the Canadian Geological Survey by myself and assistants.

Access to this, the southern portion of the Rocky Mountains within Canadian territory, being now readily obtained by the railway, its mineral and other resources are receiving attention, while the magnificent alpine scenery which it affords is beginning to attract the attention of tourists and other travellers.

The results of the reconnaissance work so far accomplished are presented in the form of a preliminary map, accompanied by descriptions of routes and passes, and remarks on the main orographic features of the range.[1]

IV.—THE ANORTHOSITE ROCKS OF CANADA. By FRANK D. ADAMS, Geological Survey of Canada.

THIS series of rocks has also been called the Upper Laurentian or Norian series. The name anorthosite is perhaps preferable, as it refers to their distinguishing characteristic as compared with the orthoclase rocks of the Lower Laurentian, viz. the predominance in them of plagioclase or anorthose felspar. These rocks form detached areas in the great Laurentian districts, and bear a strong resemblance in part to the gabbros and gabbro-diorites of Scandinavia, and in part to the labradorite rock of the same country. It is, however, by no means certain that the rocks of the two countries are of the same age. At least nine of these areas are now known to exist in Canada, and there is also one in the State of New York. In addition to plagioclase, which generally predominates largely, these rocks contain rhombic and monoclinic pyroxenes (including augite, diallage, hypersthene, and probably enstatite), olivine, magnesia, mica, spinel (including both pleonaste and picotite), garnet, iron-ores, pyrite, and apatite. Orthoclase is seldom or never found, except in veins cutting the anorthosite. The hornblende, mica, and pyroxenes are intimately associated and often intergrown, all of them sometimes being found in the same thin section. Garnet occurs sparingly, and generally near the contact of the anorthosite with the gneiss. When the olivine comes against plagioclase, it is always bounded by a double concentric zone, the outer zone consisting of hornblende, and the inner, or that next to the olivine, consisting of a pyroxene. While the iron-ores associated with the Lower Laurentian gneisses are generally free from titanium, those associated with the anorthosite rocks are always highly titaniferous; a fact which makes the study of these rocks a matter of considerable economic interest. The anorthosite varies a good deal in composition, some areas, for instance, being rich in olivine, while others are destitute of that mineral, and different portions of even the same area often showing wide differences in this respect. The rock also shows a good deal of variation in structure. It is rarely quite massive, frequently well foliated, but usually consists of a rather coarsely crystalline groundmass, through which are scattered irregular strings and masses composed of iron-ore, bisilicates, and mica, as well as larger porphyritic crystals of plagioclase. Even when it is tolerably constant in composition, there is generally a great variation in size of grain, coarse and fine alternating in rude bands or rounded masses. In the case of some of the areas there can be but little doubt that the anorthosite is eruptive, in others, however, it seems to be interstratified with the Laurentian gneiss, and in one of them to merge imperceptibly into it. The original relations of the rocks are, of course, much obscured by the effects of subsequent heat and pressure. The evidence at present, however, seems to indicate that these anorthosites are the result of some kind of extravasation, which in those early times corresponded to what in modern times we call volcanic eruption.

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[1] See Reports and Maps Geological Survey of Canada.

V.—Notes on the Crystalline Schists of some parts of Ireland.

By C. Callaway, D.Sc., M.A., F.G.S.

THE author gives a summary of results obtained by a preliminary survey of the principal areas of Irish metamorphic rocks, viz.—

1. Donegal, including parts of the adjacent counties of Londonderry and Tyrone.

2. Connemara, extending the term to cover the region lying between Westport, co. Mayo, and the granitic mass west of the town of Galway.

3. The south-eastern corner of the county of Wexford.

In each of these areas the following facts were observed:—

(*a*) A series of hypometamorphic rocks, consisting typically of fine-grained schists, altered grits, and quartzites. A clastic structure is more or less distinct in the three areas, but is least evident in Connemara.

(*b*) A group of highly crystalline schists, displaying no trace of an original sedimentary origin, dipping as if it passed below the hypometamorphic rocks. At Wexford there are true gneisses. In Connemara the rocks are less felspathic, the chief types being quartzose gneiss, quartz-schist, mica-schist, hornblende-schist, quartzite, and crystalline limestone. This description will also apply to Donegal.

(*c*) Granite, underlying (*b*), and in Connemara and Donegal clearly intrusive.

The author urges that this analogy is not due to the metamorphic action of the granite; for—

1. The mineral characters apparent in the schists adjacent to the granite are uniformly distributed through the lower series from bottom to top.

2. The evidence collected is hostile to the view that this lower series ever graduates into the upper.

It is concluded that the balance of proof is in favour of the Archæan age of the bulk of the Irish schists.

1. In the Wexford district the schists are thrown against Cambrian and Ordovician rocks by faults, and do not pass into them in the localities alleged by the Irish Survey.

2. In Connemara conglomerates of Llandovery age contain large rounded fragments, not only of the older schistose series, but also of its intrusive igneous rocks.

3. In the Ulster region the metamorphic area is separated from the Ordovician rocks of Pomeroy by a ridge of granite and diorite three miles in breadth.

The lithological analogies between the Irish schists and the Archæan rocks of Anglesey and other British metamorphic districts are also of weight in the argument.

VI.—On the Discovery of Fossil Fish in the New Red Sandstone (Upper Keuper) in Warwickshire.

By the Rev. P. B. Brodie, M.A., F.G.S.

THE author observed that, considering the thickness and extent of the New Red Sandstone in Great Britain, the paucity and rarity of fossils was remarkable, especially when compared with the abundant fauna and flora of the Trias in Europe. In a field so comparatively barren any addition, therefore, to either is interesting to the palæontologist. Many years ago the author discovered a ganoid fish—the last apparently of the genus *Palæoniscus superstes*—figured and described by the late Sir Philip Egerton (Journ. Geol. Soc. vol. xiv. p. 164) in the Upper Keuper at Rowington (six miles north-west of Warwick); and he now records another discovery of several small fish near there, probably *Semionotus*—at present in Dr. Traquair's hands—which is the first time this genus has been recorded from the British Trias. The remains of small Cestracionts are not unfrequent in one particular band of sandstone in Warwickshire and Worcestershire, with occasional footprints in the former county of *Labyrinthodon*. Ganoid fish are so rare that these above named are, as far as the author is aware, the only ones known, with one exception, which cannot be secured, in the Upper Keuper; the curious *Dipteronotus* having been found in the Lower Keuper (waterstones) at Bromsgrove, in Worcestershire. The author gave a section of the quarry containing the fossils above referred to, and stated that he considered that the New Red Sandstone in Warwickshire, as the Rev. J. Mello has adopted in Cheshire, might fairly and advantageously be divided into Upper and Lower Keuper, the two series of sandstones being different lithologically, and being separated by a considerable thickness of red marl, the lower sandstones being especially characterized by remains of *Labyrinthodon* and other peculiar reptiles, a fine and unique collection being preserved in the Warwick Museum.

VII.—ON THE RANGE AND EXTENT AND FOSSILS OF THE RHÆTIC FORMATION IN WARWICKSHIRE. By the Rev. P. B. BRODIE, M.A., F.G.S.

THE author in this paper first gives an account of the range, thickness, and fossils of the upper portion of the Rhætic formation—viz. the 'White Lias,' supposing that it really belongs to this, but to which it is now generally assigned, showing that it is very rarely seen in conjunction with the underlying shales, and that where they occur in one or two important sections the White Lias is absent. A list of the fossils is given, which are few and ill-preserved, *Ostrea intusstriata* and a species of *Avicula* (*Monotis*) being the most characteristic. A full account is given of the succeeding grey and black Rhætic shales with occasional intercalated shelly limestone and sandstone; and though, as a rule, good sections are rare, there were certain railway-cuttings which laid open several very interesting and instructive ones, and enabled the author to obtain a series of characteristic fossils, including the Radiata, by no means common and local, the *Ophiolepis Damesii*. It was stated that these occupied a considerable area in the southern division of the county, appearing again on the north-east, near Rugby, and as a rule succeeded by the basement beds (insect and saurian beds) of the Lower Lias, which were in places seen in conjunction with these shales. It was further observed that they probably underlie the Lias in its course through the county; and the author concluded by showing the general range of the Rhætics from the coast of Devon to the coast of Yorkshire; which, although not comparable either in thickness or abundance and variety of fossils with the rich, varied, and peculiar

Continental series, is still sufficiently marked and important in this county and elsewhere to make it a distinctive and independent formation.

VIII.—On the Silurian Rocks of North Wales. By Professor T. M'Kenny Hughes, M.A., F.G.S.

The author begins by describing some sections in the Silurian rocks of North Wales. Some of them are in the lower part, some in higher beds. He gives lists of fossils from the various horizons in each. He then, by means of these and by what he calls syntelism, that is, the occurrence of similar sequences of beds of the same characters, lithological or other, points out the corresponding parts of the various sections described.

He then does the same for the Silurian of the eastern borders of the Lake district, and, having in this manner constructed a vertical section of each, compares the two districts and shows that there is an identical series in each, with all the important zones of one represented in the other, except that in the part of North Wales which he has worked out he has not yet detected beds as high as the newer part of the series in the Lake district.

IX.—Notes on some Sections in the Arenig Series of North Wales and the Lake District. By Professor T. M'Kenny Hughes, M.A., F.G.S.

In this paper the author describes a number of sections which cross the Arenig series in different parts of England and Wales, and endeavours to explain some apparent discrepancies in what is generally a remarkably constant set of beds.

He starts with the Portmadoc section, where he considers that the chief differences of opinion have arisen from mistakes in the explanation of the geological structure of the district, especially from the wrong identification of some grit bands on opposite sides of important faults.

Following the series to the north he shows that, although they vary in thickness, the principal zones are still represented near Carnarvon; and, discussing the question of the unconformity of these beds on the Lower Cambrian, he points out that the Lower Cambrian rocks are seen to vary so much both in character and thickness within short distances in the neighbourhood of the existing outcrop of the Archæan that any argument founded upon their thinning-out or their different texture must be received with distrust in an area where they are known to have been deposited on the flanks of mountain ranges of pre-Cambrian age.

He then describes some localities in the Lake district where the occurrence of the same zones has been determined, and points out the difficulty of getting rid of such great thicknesses of deposits of fine mud as would be implied in the usual interpretation of those areas.

X.—On the Pleistocene Deposits of the Vale of Clwyd. By Professor T. M'Kenny Hughes, M.A., F.G.S.

The author cautions observers against inferring too hastily the glacial origin of beds from their containing glaciated boulders.

He describes the drifts of the western part of North Wales, grouping them under two heads:—

1. The Older or Arenig Drift, or that in which boulders were transported from Arenig into the Vale of Clwyd; and

2. The Newer or Clwydian Drift, or that due to the destruction of the older glacial deposits by marine action, during which boulders were carried on floating ice from the north, and flints travelled in the shingle round the coast. All the shells found in it are of species still living on the adjoining coast: but some of the shells found in what he considers part of the same series of deposits in neighbouring districts are of a more arctic type, and may belong to an earlier part of the same epoch.

He then gives an account of the principal caves explored about the Vale of Clwyd, and explains their relation in each case to the drifts of the district; inferring that, while some of them may be older than the marine Clwydian drift, and some may possibly be even preglacial, yet that none of the bone-deposits so far found in any of them can be referred to so early a date.

XI.—Supplementary Note on Two Deep Borings in Kent. By W. Whitaker, B.A., F.G.S., Assoc.Inst.C.E.

THE paper "On Deep Borings at Chatham," communicated in abstract to the last meeting of the Association, was afterwards read, with various additions, to the Geological Society. Since then, however, further information has been got, some of which is of importance, especially in view of the fact that the South Eastern Railway Company is about to make a deep trial-boring at Dover.

The boring at Chattenden Barracks, near Chatham, has been finished, being taken to a depth of over 1160 feet, the bottom of the Gault being reached at 1162 feet, where sand (Lower Greensand) was found and water got. In my account of the section it was left, in Gault, at 1103 feet, and I ventured to say that "some 60 feet more would reach the bottom of that formation"; this happened in 59 feet. I did not venture, however, to predict the finding of Lower Greensand, as, from the thinness of that series at Chatham, a little southward, it was quite possible that it might soon disappear northward.

The almost exact correspondence of the combined thickness of Chalk and Gault here, 872 feet, with the same total at Chatham (875 and 878 feet in two borings) is noteworthy. Of course there is no Upper Greensand, which formation is absent at the outcrop on the south.

The Dover boring has been carried a few feet deeper and abandoned. I have visited the site, and procured a good set of specimens of the bottom clays, of which we had but a few small pieces before.

These specimens have been carefully examined, and the result of this examination is, I think, worthy of notice. As regards fossils it is simply negative, my colleagues, Mr. G. Sharman and Mr. E. T. Newton, after washing and sifting pieces of many specimens, were unable to detect any organism, with a solitary exception, and *that* was a simple example of a species of *Rotalia*, which, struggling into existence in Silurian times, has managed to survive to the present day! I have some doubts, too, whether this one fossil may not have fallen down the bore. Anyway it proves nothing. As regards the character of the beds, however, I think that a reasonable conclusion may be inferred from the specimens.

In my published account certain beds are referred, with some doubt, to the Lower Greensand. The reference is wrong and the doubt right, for the top five feet, of the 49 credited to Lower Greensand, really belong to the base of the Gault, and the bottom thirteen feet to the Wealden, as I believe. The Lower Greensand is left, therefore, with only 31 feet of clayey sand. It is curious that specimens from the bottom part (838 to 848 feet) are exactly like the corresponding specimens from the bottom part of the Lower Greensand in the Chatham boring (932 to 943 feet), the two sets having about the same vertical extent (10 or 11 feet).

These specimens remind one of the division known as the Sandgate Beds, and I am inclined to think that this division alone occurs at Dover, the Folkestone Beds above and the Hythe Beds below having thinned out, although both those divisions are thicker than the Sandgate Beds at the outcrop.

The clayey beds beneath have been proved to a thickness of some 80 feet, the boring ending at about 930 feet. In my paper I spoke of chalky matter occurring in them, but in this I was wrong. The white specks in the small specimens first seen certainly looked calcareous, but the examination of better specimens has shown that they are anything but that. Indeed, the prevailing character is the absence of any effervescence when the clays are treated with hydrochloric acid; in many cases peculiarly fine-grained whitish beds simply absorb the acid, without any effervescent action.

On comparing the specimens with other clays, they were found to be unlike any of the marine Cretaceous and Jurassic clays, and it seemed to me that their affinities lay rather with the Wealden series, and probably with the lower, or Hastings division, than with the Weald Clay.

I have only lately been able to test this by the help of a set of specimens that Mr. G. Maw has been kind enough to send me. On examining them I found that three specimens of Weald Clay, from Surrey, effervesced readily, which is perhaps not surprising as they came in two cases from close to Horsham stone, and in the other from near a Paludina-bed. Nine specimens from a more distant district, Dorsetshire, did not effervesce; but one can hardly give the exact position of these in the Wealden Series. Ten specimens from the Ashdown Series, the lowest division of the Hastings Beds, not only, in some cases, resembled Dover specimens in character (I speak from memory, not having had the two sets side by side), but in every case refused to notice the presence of hydrochloric acid.

Should this classification be right, it serves to strengthen very much the conclusion, in my paper, that Dover is on all grounds a good site for a deep trial-boring,[1] for it looks as if the bottom part of the great Wealden Series came there within 600 feet of the surface in the low ground, the boring being described on a site 280 feet above the sea.

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[1] Quart. Journ. Geol. Soc. 1886, vol. xlii. p. 44.

REVIEWS.

I.—Department of the Interior. Report of the United States Geological Survey of the Territories. F. V. Hayden, United States Geologist-in-Charge. Volume III. The Vertebrata of the Tertiary Formations of the West. Book I. By Edward D. Cope, Member of the National Academy of Sciences. (Washington, Government Printing Office, 1883.)

(*Continued from p.* 477.)

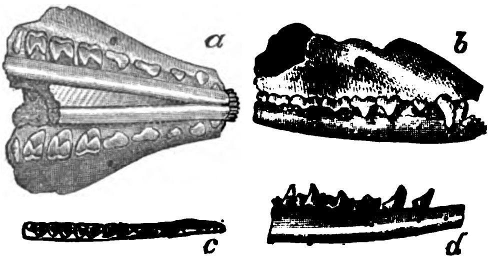
THE rocks of Middle Tertiary Age, which are found in the far west of the United States, are calcareous clays and marls, alternating with light-coloured sandstone. In Oregon they are often old trachytic muds, three to four thousand feet thick, and about 2300 feet thick in Nevada. But on the White River in Nebraska the thickness of these rocks is reduced to 150 feet, and there the strata are divided by Hayden into eight zones. The Oregon beds are typically seen on the John Day River, so that the White River and the John Day beds are regarded as equivalent, and belong to the Miocene series. These rocks hitherto have yielded no Fishes or Amphibia, and no traces of Birds; so that the discussion of their fauna is limited to Reptiles and Mammals.

The striking feature of the reptilian life, as compared with that of the older Eocene series, is the absence of Crocodiles, the decrease in number of species of Tortoises, with an increase of Lizards and Serpents. But none of the Reptiles are remarkable for size, and are similar in proportions to those now living in the same region. The author commences with the genus *Testudo*, which is represented by five species in the White River beds of Colorado. They are distinguished by the form of marginal bones, the shape of gular scutes and other characters. *T. quadratus* is the largest, *T. laticuneus* the best preserved. Some of the species are only described from a few bones, because the difficulties of transport compelled the author to select such as were most characteristic, often leaving the bulk of the specimens behind. The only other Chelonian is Leidy's *Stylemys nebrascensis*.

The Lizards are for the most part founded upon fragmentary remains. *Peltosaurus*, however, is well preserved. In this genus the temporal fossa is not roofed over by bone, but is rather small; the orbits are large. Two median dermal scutes, which represent the interparietal and postinterparietal plates, have left impressions on the parietal bone. The genus is distinguished from *Gerrhonotus*, by having had the body covered with bony scutes, which were rectangular, and arranged in transverse bands, joined at the sides by minute sutures, and overlapping in an imbricated method. The hexagonal scutes on the skull are one of its most distinctive characters; one species is known. *Exostinus*, very imperfectly known, appears to be related to *Peltosaurus*, but that genus has the frontal region much wider, and wants the tubercles along the supra-orbital border. *Aciprion formosum* is a Lizard known from a dentary bone, with closely-packed cylindrical pleurondont teeth, having compressed crowns with three cusps, the median one large and those at the sides small. *Diacium quinquipedale* is founded on a sacral vertebra which has no trace of a neural spine; and indicates an animal as large as any of the living Iguanidæ. The genus *Platyrhachis* is only known from vertebræ which have the centra much impressed, the neural spine reduced to a low keel, and the ridge connecting the zygapophyses deeply notched, a character which distinguishes these vertebræ from those of *Peltosaurus*: three species are known. *Cremastosaurus carinicollis* is a Lizard known from cervical vertebræ, somewhat like those of *Phrynosoma cornutum*, but with relatively small cup and ball articulations, and a strong rib-like hypapophysis.

There are four genera of Snakes founded on vertebræ, which are the only parts hitherto discovered. *Aphelophis* is very like the living genus *Charina*, though the zygosphene is wider. *Ogmophis*, known from two species, is an allied type, distinguished by the ridge which extends from the parapophysis, and the groove which lies between that ridge and the middle line of the centrum. *Calamagras* is a similar type, but intermediate between the two last named. *Neurodromicus* has vertebræ which resemble those of one of the Crotalidæ, but has no process below the prezygapophysis, and has the hypapophysis less robust.

The Mammalia of the White River period are not less numerous than those of the Bridger and Wasatch rocks, but a great change has come over the fauna. All the Amblypoda have disappeared, and there are no representatives of the Tæniodonta, Tillodonta, or of the Lophiodonts; while the Creodonta and Mesodonta are rare. No species of mammal found in these rocks is common to the underlying Eocene series. The Miocene species reach a larger average size, particularly among the Perissodactyla and Carnivora. Life would appear to have been abundant; for the author states that many of the species are represented by great droves, and their bones form beds of considerable extent. The Marsupialia is represented by doubtful types, some of which have already been referred to the Creodonta, and are only placed with the Marsupials provisionally. *Peratherium*, though represented by six species, is only known from the cranium and mandibles. An excellent discussion is given of its dental characters, with the result that the teeth differ from those of



Peratherium fugax.

Didelphis in the elevation of the median cusps of the superior true molars into Vs, and in the tubercles of the external series becoming obsolete. All the species are founded on dental characters. *Mesodectes* and *Geolabis* are referred provisionally to the Creodonta. The former is intermediate between *Leptictis* and *Ictops*, the last premolar having a single sharp cusp as in the former genus, with an internal cusp or heel like that of the latter. The cranial characters are like those of *Leptictis*, and the molars and some other features recall the living genus *Solenodon*. The presternum has a prominent keel in front, like that of a bird. The cerebral hemispheres and cerebellum are a little wider than long, and together have a subquadrate outline. The only species known is about the size of the Hedgehog. *Geolabis* is only known from crania, from which the molar teeth are wanting, and the author is uncertain whether it may not be identical with *Domnina*. *Menotherium lemurinum*, though placed under the Insectivora, is regarded as the first indication of a Lemur in the Miocene of the United States, and indicates an animal as large as the domestic Cat. The genus *Domnina* is referred with some doubt to the Cheiroptera. It has the posterior external cusp of the true molar teeth in the form of a crescent, like the anterior cusp, only rather smaller; both internal cusps are at the summits of strong ridges: two species are described.

The order Rodentia is represented by no fewer than thirty-one species and eight genera, of which *Sciurus*, *Hesperomys* and *Lepus* are found living in the same region, and all the fossil species of Rodents belong to the three great divisions of the order which now inhabit North America. The author observes that the feet and teeth in this order present a succession of changes in structure with time. The earliest known forms, allies of the Squirrels, belong to the suborder Sciuromorpha. In them the trochlear structures of the humerus and tibia are but little developed, they are plantigrade, with five digits, and the fibula is not co-ossified with the tibia, while their teeth have nearly always long roots and short crowns, and are rarely prismatic. An advance on this generalized type is seen in the suborder Histricomorpha (which has a single representative in the Loup Fork beds), in many of its members having a reduced number of digits and prismatic dentition. In the third suborder, Myomorpha, the tibia is found co-ossified with the fibula; many genera have prismatic teeth, some a reduced number of digits, and a few, comprising the Jerboas, have the metatarsal bones blended together. Finally, the Rabbits add to these specialized characters a primitive character in the presence of four superior incisor teeth; and the author is disposed to believe that the Rodents are either direct descendants from the Marsupials, or that the Rabbits may represent the suborder Tillodonta of the Eocene. The differentiation of the Rodent suborders, however, must be anterior to the Miocene period, for the Squirrel tribe has already occurred in the Lower Eocene. The Myomorpha appear in the John Day beds, but without prismatic teeth, while the Lagomorpha are typically developed in the White River beds, and a true Porcupine represents the Hystricomorpha in the highest Miocene. There is, moreover, an interesting affinity between the extinct and living genera, in the circumstance that all the ancient genera differ from their modern representatives in the greater constriction of the skull behind the orbits, acccompanied by an absence of postorbital processes. The genus *Sciurus* is known from three species, two of which are about the size of the grey and red Squirrels of North America. *Gymnoptychus* appears to be a Squirrel nearly related to *Sciurus*, but differs in having the tubercles and crests of the molar teeth more complex than in any existing genus, except *Pteromys*. There are two species which differ in size and in proportions of the lower molar teeth.

Meniscomys is another type in which the dentition resembles that of *Pteromys*, but differs in the upper molars wanting the re-entering inflexion of the enamel. Four species are described, which differ in the length of the roots of the molars, in the character of the dental crests, and the plications of the inferior molar teeth.

It is observed that there is a suggestive resemblance between *Meniscomys hippodus* and *Haplodontia rufa*, now living in Oregon, which is indicative of a common origin. This ends the history of the true Squirrels.

Ischyromys is the type of a distinct family; for, though it resembles the Squirrels in dental characters, the infraorbital foramen occupies the position, at the origin of the zygomatic arch, seen in Porcupines and Cavies. The superciliary ridge and postorbital process, seen in most Squirrels, is lost; and there is a contraction between the orbits, which approximates towards the Beaver. Beavers are represented by two species of the genus *Castor*. *C. peninsulatus* is about the size of the large prairie Marmot, and is abundant in the Miocene rocks of Oregon. *C. gradatus* is somewhat smaller. *Heliscomys vetus* is the smallest Mammal of the White River beds, being about the size of *Mus musculus*. Its affinities are open to some doubt; the four inferior molars have crowns with four cusps in two transverse pairs and a broad ledge on the external side of the cusps.

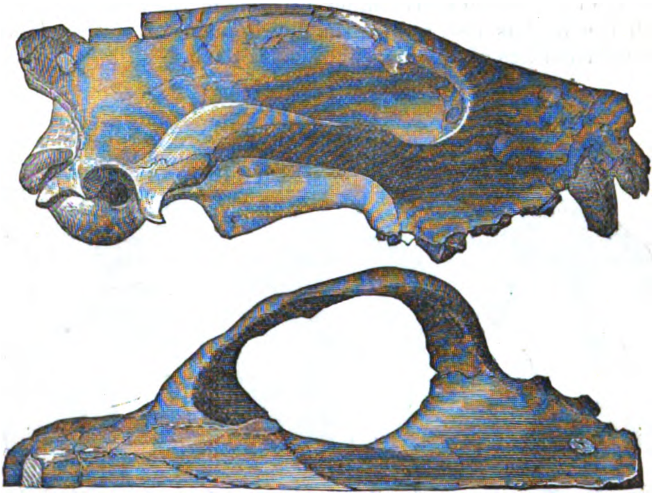
The Myomorpha are represented by two families, Muridæ and Geomyidæ. *Eumys elegans*, of Leidy, is a Rat found in the White River rocks in Eastern Colorado, previously known from Dakota. The molar teeth are as large as those of the Norway Rat, but the muzzle only two-thirds as long, so that the animal was smaller and more robust. *Hesperomys nematodon* is a representative of an existing genus, and indicates a Rat as large as the red Squirrel. The genus *Paciculus*, which has three superior molars, differs from *Sigmodon* and *Neotoma*, in having three external inflexions of the enamel, instead of two, in the upper molars. *Entoptychus*, known from five species, is referred to the Geomyidæ. The molar teeth are four above and four below, rootless, with prismatic crowns, which differ from those of *Perognathus*, in having the enamel loop cut off and isolated. The skull wants the vacuities and large foramina seen in many Rodents. The bones of the skeleton in general resemble those of the genus *Thomomys*. The species are defined by the characters of the superciliary borders, the length of the skull, and width of the premolars. The species are found in the John Day beds of Oregon. *Pleurolicus* is another member of the same family. It is represented by two species, and approximates to the existing genera *Heteromys* and *Perognathus*, from the latter of which the most distinctive difference is the grooving of the upper incisors.

The Lagomorpha is represented by three genera. *Palæolagus* is a type which approximates towards *Lepus*, but it has no postfrontal process, and the first inferior molar consists of one column, more or less divided. A cast of the cerebral chamber shows that the olfactory lobes are large, expanding abruptly from the hemispheres, from which a constriction separates them. They are wider than long, and wider than the front of the cerebrum. The brain was smaller than in the Rabbit, and in the *Palæolagus haydeni* the cerebral hemispheres are smaller, and the olfactory lobes larger. The number of teeth is the same as in existing Rabbits, but with age many changes appear, which at first suggest the characters of different species.

P. haydeni was widely distributed in Dakota, Colorado, and Oregon. It is thought to have been the progenitor of *Lepus sylvaticus*, which now inhabits North America. *P. triplex* was rather larger than the prairie Marmot. *Lepus emisianus* is the only species of the genus found in the John Day River beds. It is distinguished by the free short postorbital processes, which are narrower than in *L. auduboni*, and behind these processes the cranium is narrower. The mandible has the form of *L. sylvaticus*, which the animal resembled in size. The remainder of the volume is devoted to the Carnivora.

From the views already developed by the author, it is interesting to find the Carnivora distinguished as clawed Mammalia with transverse glenoid cavity of the squamosal bone, confluent scaphoid and lunar bones of the carpus, and well-developed cerebral hemispheres. A good deal is made of the cerebral hemispheres, because some Insectivora possess a united scapholunar bone. Hence the crucial fissure of the hemispheres, which is present in all Carnivora, except one or two of the Melinæ, becomes as important a characteristic as the absence of the parieto-occipital, and calcarine fissures. The author makes two primary divisions of the order: first, Hypomycteri, in which the external nostril is occupied by the complex maxillo-turbinal bone, while the ethmo-turbinal bones are confined to the hinder part of the nasal fossa, and the inferior ethmo-turbinal is of small size; and, secondly, the Epimycteri, in which the external nostril is occupied by the inferior ethmo-turbinal and the reduced maxillo-turbinal. The Hypomycteri stand next to the Pinnipedia, since the maxillo-turbinal bone has the same anterior development in that group. The division of the groups into families depends upon the presence of sectorial teeth, which are defined as having at least two external tubercles, and by the flattening and emargination of their continuous edges the sectorial blade is formed. Other characters are found in the number and form of the molars, the presence or absence of an alisphenoid canal, the character of the otic bulla and the number of toes.

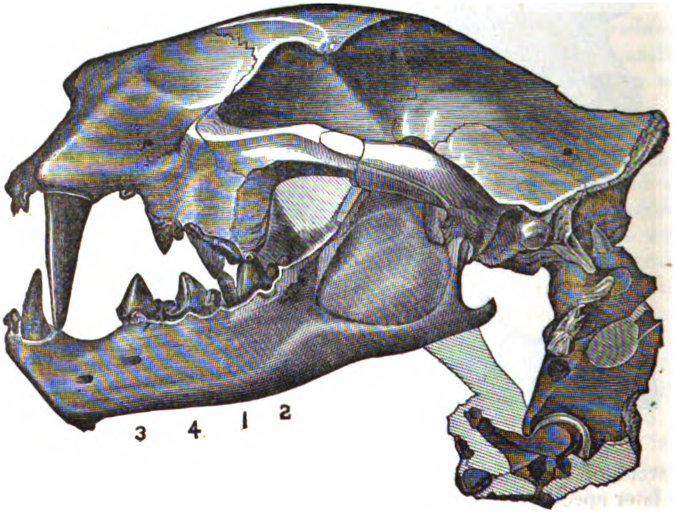
The Canidæ were abundant in the Miocene of North America, but in the lower and middle portions of the deposit the genera are allied to *Canis*, while in the Upper Miocene or Loup Fork beds the genus *Canis* prevails. Eight genera of Dogs are here represented by twenty-five species. *Amphicyon* of Lartet is known from three species. *A. cuspigerus* is not larger than the Kit Fox; *A. hartshornianus* is about the size of a Coyote, and *A. vetus* rather larger. *Temnocyon* has four species, and is distinguished from *Canis* by the presence of a cutting edge on the superior face of the heel of the inferior sectorial, in place of a double row of tubercles surrounding a basin. This keel is a repetition upon that tooth of the heel seen in the posterior premolar teeth of many Carnivora. The genus approaches most closely to the French form *Cynodictis crassirostris*. On *Temnocyon coryphæus* the author observes that the dimensions were about those of the *Canis latrans*, but the face was short. The brain-case is smaller than in the Coyote. The genus *Galecynus* of Owen is well represented by four species, which are characterized by the relatively small size of their sectorial teeth. The internal tubercle of the inferior sectorial is more largely developed than in the later species of Dogs, and thus approaches some of the Viverridæ. The genus is separated from *Canis* by the presence of the epitrochlear foramen of the humerus, a character shared with *Amphicyon* and *Temnocyon*. *G. gregarius* is only about half the size of the Red Fox. *G. geysmarianus* was about the size of *Mustela pennanti*: it stood lower on the legs than a Fox, had a body as slender as the most vermiform of Weasels, and a tail as long as in the Ichneumons. *G. lemur* is the smallest species yet discovered in the Miocene of Oregon. *Enhydrocyon* has the canine type of dentition, but in the form of skull resembles the Polecat and Otter: but one species is known, which was probably as large as the Coyote.



Enhydrocyon stenocephalus.

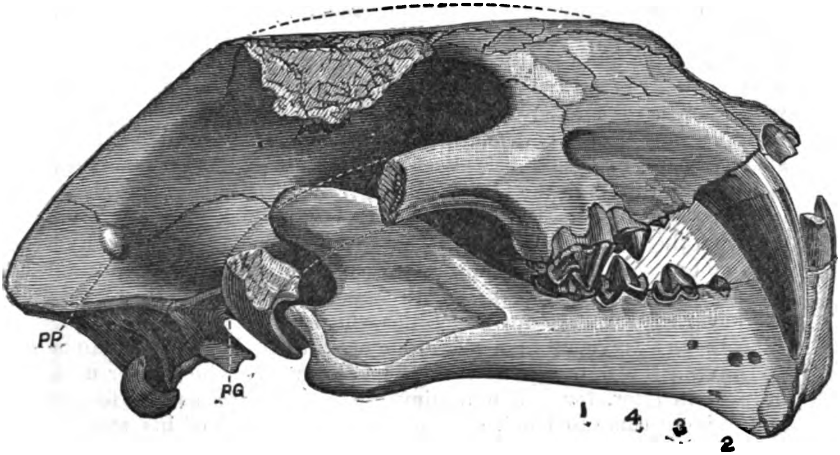
Oligobunis crassivultus differs from *Icticyon venaticus* of Brazil, in the greater development of the inner part of the upper tubercular molar, while the tubercular molar of the lower jaw is much less developed. *Hyænocyon* differs from *Oligobunis* in wanting the first premolar and the second molar teeth in both jaws. *Bunælurus* is allied to *Putorius* and perhaps to *Gulo*, but is distinguished by the form of its tubercular tooth, which is a cutting tooth without cusps or tubercles.

In the higher genera of the family Nimravidæ, the dental characters are like those of the Felidæ, but among the lower genera the number of molar teeth increases anteriorly in the upper jaw, and at both ends of the series in the lower jaw; though the number of true molars never exceeds one above and two below. Eight genera are at present grouped in this tribe; and they show modifications in the reduced number of molars, the enlarged size of the upper canines, smaller size of the lower canine, conical form of the crowns of the incisors, addition of a cutting lobe to the anterior base of the upper sectorial tooth, the obliteration of the inner tubercle of the lower sectorial in which the heel is lost, and in the development of cutting lobes on the hinder borders of the larger premolar teeth.



Nimravus gomphodus.

Some of these genera may belong to the Cryptoproctidæ; but until the number of digits is known in all the forms, this point cannot be determined. *Archælurus debilis* was an animal having much the aspect of existing Cats, but with more slender feet, narrower head, and greater convexity of the region between and behind the eyes. The prehensile organs of the feet, and teeth, were less robust. It was about the size of the American Panther. There is no cutting edge to the front of the canine tooth, and the posterior edge is not serrated. The sectorial teeth have a long narrow form, the superior tooth has no anterior lobe, and the inferior tooth has no internal tubercle, but the heel is present. *Nimravus* is known from two species nearly allied to *Archælurus*, but distinguished by wanting the anterior premolars in both jaws, while the large canine in the upper jaw is denticulated. In dental formula and characters, it resembles *Hoplophoneus*, with the addition of a tubercular inferior molar tooth There is no evidence to show the length of the body. The canine teeth were probably exposed; and, as penetrating weapons, are unrivalled among carnivorous animals. Three species of *Dinictis* are described; it is a primitive sabre-tooth genus, closely connected with the false sabre-toothed group. The superior canine is long and compressed, and rests against an inferior marginal flange of the mandible, whose surface is divided from that of the symphysis by a strong angle. *Pogonodon* connects *Dinictis* with the higher sabre-toothed genera, but wants the tubercular lower molar of *Dinictis*, while it possesses the second inferior premolar which is wanting in *Hoplophoneus*. The species are the largest of the North American sabretooths.



Pogonodon platycopis.

P. platycopis is equal to the largest *Drepanodon*, and only inferior in size to *Smilodon*. The skull is equal in size to the largest Brazilian variety of the Jaguar. The molar teeth are rather small, the second sectorial is primitive, and peculiar in its robust heel. *Hoplophoneus* is a genus with the dental formula of *Drepanodon* and the true Cats, but which retains the primitive form of the sectorial teeth in the lower jaw. The type-species was as large as the Canadian Lynx, with long and slender upper canines. Three species are described. Here Book i. terminates, leaving the remainder of the John Day fauna, as well as that of the Pliocene period, for description in the second book of volume iii. The beautiful plates by which the text is illustrated reflect credit upon the artists, as well as upon the

Government Department which issues them, and will always make this work one of the standard landmarks in the history of Mammalian life.

As we close the book, it is with an earnest desire that the same devotion of the Department of the Interior to the interests of Science which has placed this magnificent contribution before the world, may at no distant date be able to secure the publication of the remainder of the author's contributions to a knowledge of the fossil Vertebrata of the United States Territories. It is, we believe, known that the materials for these histories have been in part gathered by many adventurous explorations, and not inconsiderable expenditure by the author; and that the United States Government has already spent large sums of money in preparing plates to accompany the text, which remains in their hands unused. We venture to believe that the gratitude which scientific men feel for the work already published, emphasizes the hope that it may be speedily completed; for it is one of the most valuable contributions to knowledge ever made by an individual, and its publication reflects honour on the nation.

When we survey the enormous range of Professor Cope's work, which has enriched every department of the Vertebrata with new materials, often interpreted with strikingly original conceptions, it is impossible not to bear witness to the magnitude of labours which derive their chief value from the genius which directs them. Shortcomings are easily detected, but when balanced against valuable achievements, may well be passed over. Most of the great writers on similar subjects in the Old World have secured honour by selecting for their labours, materials more or less perfect, which left no doubt on their interpretations. Obscure and difficult specimens have been laid on one side until later discoveries or maturer powers in the writer, removed the obscurities. Professor Cope, on the other hand, has never shrunk from any difficulties which his materials presented. A tooth, or a fragment of a mandible, or an ankle bone in his hands has revealed a new type of life. The discoveries which other men have waited for, for half a lifetime, he has utilized as the fossils successively came to hand, so that the nomenclature of his species has changed, and the interpretation of organic structures has gradually unfolded results of increasing value. There is hardly any writer whose work, looked back upon after a quarter of a century, does not show that, here and there, interpretations might be improved. Such improvements Prof. Cope has been able, in many cases, to make in a much shorter time by unceasing industry, and vigilance to seize new truths as they appeared. Work like this, upon fragmentary fossils, appeals with most powerful interest to those whose knowledge enables them to appreciate this daring faith in scientific methods, which is hedged round with reasons for the results proclaimed. And it is only when these earlier judgments are in so many cases sustained by later work on better specimens, that the discriminating insight manifested justifies such methods of work.

The results at which the author has arrived in this first book of volume iii. are modestly stated by himself under fifteen heads, including such matters as the discovery of the Laramie genus *Champsosaurus* in Tertiary beds, the discovery of Tertiary allies of *Plagiaulax*, the discovery of five families and many genera of Creodonta, the discovery of the Periptychidæ, the Menisootheriidæ, the Phenacodontidæ, the discovery of characters of the suborder Condylarthra, the characters of the Pantolambdidæ, of the suborder Taligrada, of the Anaptomorphidæ, the reconstruction of *Hyracotherium* and *Hyrachus*, the discovery of many Marsupials in the Lower Miocene, and of ancestors of the Cats and Dogs; to which may be added the description of three hundred and forty-nine species, all discovered by the author, except thirty-two. But although the present volume may not claim to have first set forth the greater results to which these are but some of the stepping-stones, we may point to the method of comparison of the fossil types with each other and with living genera as indications of the sources of knowledge by which the grouping of families and genera has been produced, which has given rise to new ordinal and sub-ordinal groups and improved classifications. The conception of the Bunotheria will always remain one of the most interesting of these results, because it is the first attempt to apply the principles of evolution to Mammalian classification in its larger grouping. The Amblypoda introduces a new hoofed type of life, which was already elaborated by the descriptions of Coryphodon, given in Lieutenant Wheeler's Survey in 1877. These and a multitude of minor innovations in classification are the fruits of new knowledge gathered partly from animals still living, partly from the wonderful organisms discovered in United States rocks. It is not too much to say that the light thus thrown upon the Mammalia as a whole, is more instructive as to the laws of life, and the conditions under which the component structures of animals have varied, and been evolved, than the insight gained during the same time by the study of Embryology. This harvest of fruit from the past may justify the confidence that in the history of fossil life, which has yet to be told by the palæontologist, the significance of the varied organization of existing animals will be demonstrated.

H. G. Seeley.

II.—M. L. Dollo on new Chelonians from the Eocene of Belgium.[1]

In these two memoirs the learned Assistant Naturalist to the Royal Belgian Museum of Natural History describes two new genera of Chelonians which are of very considerable interest, and also publishes a synopsis of the classification of the order, which is a modification of that proposed by Prof. E. D. Cope, of Philadelphia.

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[1] "Les Chéloniens du Bruxellien (Eocène Moyen) de la Belgique," Bull. Mus. R. Hist. Nat. Belg. vol. iv. 75-86, pls. i. ii. (1884), "Les Chéloniens Landeniens (Eocène Inférieur) de la Belgique," *Ibid.* pp. 129-141, woodcuts.

The proposed classification is as follows:

Order CHELONIA.
Suborder 1. PROCHELONIA.—Sect. MACELOGNATHA.
2. EUCHELONIA.— „ 1. ATHECÆ.
„ 2. THECOPHORA.
Subsect. 1. PLEURODIRA.
2. CRYPTODIRA. a. *Dactyloplastra.*
b. *Clidoplastra*
c. *Lysoplastra.*

The first suborder is a purely hypothetical one, and is formed for the ancestors of the known forms which are presumed to have been furnished with teeth. Apart from the general question whether it is advisable to overload scientific nomenclature with terms for hypothetical groups, it appears to us that in this instance the author would have exercised greater discretion if he had refrained from proposing this suborder, since, as Prof. A. Newton has recently shown in the case of the Birds, it does not necessarily follow that the possession of teeth by the more primitive forms of a group entails the separation of such forms from the more specialized groups which have lost these organs.

The Euchelonia comprehends all known members of the order; the section Athecæ being formed for *Sphargis* and its fossil allies; while the section Thecophora includes all other known forms. The first subsection (Pleurodira) of the latter embraces the existing family *Chelydidæ* and certain Mesozoic forms such as *Plesiochelys.* The existing members (*e.g. Chelys*, *Platemys*, and *Hydraspis*) of this subsection, which is characterized by certain features of the pelvis, and the presence of an intergular plate, are now entirely confined to the Southern Hemisphere; and it is interesting to note that while *Platemys* is represented in the Lower Eocene of England, a member (*H. Leithi*) of the South American genus *Hydraspis* has been described by Dr. Gray from the Eocene of Bombay. In the Cryptodira, which may be now regarded as the Chelonians of the Northern Hemisphere, are included all the remaining members of the order. In the first (Dactyloplastra) of the three groups into which this subsection is divided, M. Dollo recognizes four families,—the *Chelonidæ*, *Propleuridæ*, *Trionychidæ*, and *Chelydridæ*. The second group (Clidoplastra) is divided into the *Pleurosternidæ*, *Baënidæ*, *Adocidæ*, *Emydidæ*, *Cinosternidæ*, and *Testudinidæ*; while the third (Lysosterna) comprises only the *Cistudinidæ* (*e.g. Cistudo*, *Terrapene*, etc.).

We are by no means sure whether such a complicated division of the Cryptodira is advisable, especially as some English systematists (*e.g.* Dr. Sclater[1]) include the *Cistudinidæ*, *Cinosternidæ*, *Chelydridæ* (*e.g. Chelydra* and *Macrochelys* or *Macroclemmys*), and apparently the *Baënidæ* (*i.e.* if *Dermatemys* be classed in the latter) in the *Emydidæ*, and do not consider the characters on which M. Dollo relies as of more than generic value. This is, however, a matter on which every scientist who has studied the group is entitled to use his own opinion.

Turning now to the new forms described by M. Dollo, perhaps the most interesting is the one from the Bruxellien, to which he applies the name *Pseudotrionyx*, and classes in the *Chelydridæ*. This form is characterized by the absence of horny plates and the presence of a scute-sculpture, like *Trionyx*, but was apparently furnished with a complete series of marginal scutes, while the plastron, although only imperfectly united to the carapace, is much more complete than in the latter. This genus evidently forms a connecting link between the typical *Trionychidæ* and those Tortoises in which the shell is complete; M. Dollo attaches more weight to the apparent completeness of the marginal scutes than to the sculpture of the scutes and the absence of horny plates, and therefore separates the genus, together with *Anostira* and *Apholidemys* of Leidy from the *Trionychidæ*; but we cannot help thinking, from the variations in the former respect between *Trionyx* and *Emyda*, that the arguments are at least as strong in favour of the opposite view, and for taking the presence of horny plates as a characteristic of the *Emydidæ*, in the sense in which that term is used by Dr. Sclater.

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[1] See "List of Animals in Gardens of Zool. Soc." 8th ed. pp. 561-571 (1883).

The second genus, *Pachyrhynchus*, is from the Lower Eocene, and is referred to the *Chelonidæ*; it is represented not only by the typical Belgian *P. Gosseleti*, but probably also by the three forms from the London Clay described by Professor Sir R. Owen under the names of *Chelone longiceps*, *C. planimentum*, and *C. trigoniceps*. The genus is distinguished from *Chelone* by the great length of the mandibular symphysis; by the triangular form, thickness, and slight depression of the palate; the depth of the laterotemporal notches; the separation of the nasals; and by the posterior nares being separated from the anterior ones by long narrow channels, and by opening on the posterior third of the basal aspect of the cranium. These differences M. Dollo is inclined to regard as of rather more than generic value.

M. Dollo is to be congratulated on this paper, and especially on the careful diagnosis of characters distinguishing all his work.

R. L.

CORRESPONDENCE.

THE VOLCANIC ERUPTION OF NEW ZEALAND.

SIR,—Almost every geologist will have read the deeply interesting accounts and speculations by Mr. Archibald Geikie and Dr. Hector in "Nature," and of Mr. R. Etheridge, jun., in this MAGAZINE. As the district affected is one likely to be subjected to a careful investigation, may I be permitted to draw attention to a few facts of important bearing on vulcanological science that should be cleared up. In my paper on the geology of Vesuvius and Monte Somma and in other communications, it was pointed out that after a long state of quiescence of a volcano, the subsequent eruption should be of the *explosive* or *plinian* type. That is to say, the stony products should consist essentially of pumice due to the length of time that the magma had remained in contact with aquiferous strata, gradually absorbing water, and consequently the impossibility of the outflow of lava until all the water-saturated magma has been ejected. In relation with this the presence of the three divisions of the ejectamenta; the lowest or first being a very vitreous pumice, except for the presence of pre-eruptive minerals such as the felspars, amphibole, mica, and magnetite of first consolidation; the second or middle division being far more microlithic, with the presence of pyroxene or other eruptive or post-eruptive formed minerals; and the third or upper division consisting of ash due to the loss of cohesion within the magma in consequence of the advanced stage of conversion of the glassy part into "formed" or individualized matter.

In many tufas, and especially those formed from the third or upper division of the products of a *plinian* eruption, or of any pumiceous ash, there are an abundance of little pisolitic concretions of great perfection. Scrope has suggested drops of water falling in the dust as the cause of their production. To me they seem rather a segregation similar to what occurs in the felspathic and siliceous glazing cream in pottery manufacture; but there is still much doubt, and observation would be of much value if made on the new ash, as we do not know whether they are formed immediately, or after long exposure and soaking by moisture. One thing should be remembered, and that is, that a few small ones may be inclosed in a larger one, which is not compatible with Scrope's theory.

The next point is the vesicular structure in ashes, which often so well mimics that of lava, that in old decomposed rocks much doubt may exist as to whether a given mass may be a lava or a tuff. I think the drops of rain, suggested as an explanation of pisolites, is the real influence at work in producing these vesicular cavities.

Next, it would be interesting to know whether new cones (or more properly crater-rings) have been formed within the craters of explosion towards the end of the eruption.

Observations on the proportion of the *essential*, *accessory*, and *accidental* ejectamenta should be made in each of the subdivisions of the deposits, and at different distances from the centres of explosion.

Observations of the green and dry wood buried in the pumice would clear up the question as to whether the peculiar lignitization or carbonization to be seen at Pompei, not only in wood, but also in bread, fruit, cloth, grain, etc., is due to burning, baking, or subsequent decomposition. In Pompei neither glass nor lead was fused where buried by the falling pumice. This I have shown to be due to the low temperature of the pumice from the loss of heat in converting liquid or dissolved water into vapour on the relief of pressure during the eruption.

Lastly, search should be made for fulgurites, which have been met with at Pompei.

H. J. JOHNSTON-LAVIS.

THE PEA-GRIT OF LECKHAMPTON HILL.

Sir,—In the Quarterly Journal of the Geological Society just issued, there is a paper by my friend, Mr. Witchell, of Stroud, on "The Basement Beds of the Inferior Oolite of Gloucestershire."[1] The reasons for writing the paper are given under two heads, but I am only now concerned with the first. Mr. Witchell says:[2] 1. "That the beds called 'Pea-grit' in the Leckhampton section by Hugh Strickland, which name was adopted by Dr. Wright and the Geological Surveyors, included in that term—erroneously as I think—all the beds occurring between the Pea-grit proper, and the Cephalopoda bed of the sands, which beds are shown in some sections to be more than thirty feet in thickness."

Further on Mr. Witchell tells us that the "Pea-grit" and Basement Beds at Leckhampton Hill "are described as Pea-grit in the published works referring to them. Now, if Mr. Witchell will refer to the late Dr. Wright's paper,[3] "On the Palæontological and Stratigraphical Relations *of the so-called* Sands of the Inferior Oolite," he will find that in the section of Leckhampton Hill the lower beds of the Inferior Oolite are referred to as Pea-grit *and ferruginous oolite.*" That Dr. Wright was fully aware of beds of oolitic structure beneath the "Pea-grit," and which he recognized as distinct from the particular bed bearing that name, is shown by his section of Cleeve Hill,[4] in which he gives the following:—

	ft.	in.
Pea-grit	21	30
Coarse ferruginous oolite	22	5

Edward Wethered.

NOTIDANUS AMALTHEI, OPPEL.

Sir,—During a recent examination of the fossil Vertebrates in the Whitby Museum, which I have been enabled to make through the kindness of Mr. Martin Simpson, I have been fortunate enough to meet with the Liassic tooth mentioned by Tate and Blake as referable to *Notidanus Amalthei*. This specimen, it will be remembered, was not forthcoming at the time of publication of my contribution to the Palæontology of the Notidanidæ (*antea*, p. 208), and it may therefore be interesting to add a brief note upon the features it presents.

The fossil consists merely of a single laterally-compressed cone, scarcely two millimetres in height, with a very minute denticulation at the base of one edge, and fixed upon a fragment of a root. The cone has an enamelled surface, and the one side is almost plane, while the other is strongly convex; and the appearance of the tooth is certainly suggestive of other cones having been broken away from the one that remains. There can be scarcely any doubt, indeed, that the specimen belongs to a Selachian genus, and it bears much more resemblance to a dental fragment of *Notidanus* than the Swabian fossil described by Oppel, as far as the latter's figure will enable one to judge. It does not agree with the teeth of *Palæospinax* or any other Liassic Shark I have had the opportunity of studying, and Tate and Blake's determination is very possibly correct; but more satisfactory evidence must still be awaited before there is absolute certainty of the presence of *Notidanus* among the early Jurassic fauna.

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[1] Q. J.G.S. vol. xlii. part 3, No. 167, pp. 264—270.

[2] *Ibid.* p. 264.

[3] *Ibid.* vol. xii. p. 295, 1856.

[4] Proc. Cotteswold Club, 1869, "Correlation of the Jurassic Rocks of the Côte d'Or and the Cotteswold Hills."

A. Smith Woodward.

ENTOMOSTRACA IN THE RHÆTICS.

Sir,—In the Geological Magazine, May, 1886, p. 203, a slight error occurs in Mr. J. S. Gardner's interesting paper, in stating that "the valves of a species of *Cyclas* abound in the Rhætics." This should have been either *Candona* or possibly *Cypris*; the latter may be after all correct, as it is associated with the freshwater aquatic Moss, *Naiadites*. The supposed *Cyclas* has been determined to be *Estheria*, a brackish-water Crustacean, though Sowerby stated it to be *Cyclas*, when my work on Fossil Insects was published. In the Note (2) at the bottom the reference should have been not to the *Estheria* bed in particular, but to the Rhætics in general (in which the former is included), which may be considered to be junction or passage beds between the Trias and the Lias.

P. B. Brodie.

OBITUARY.

HARVEY BUCHANAN HOLL, M.D., F.G.S.

Born 28th September, 1820; Died 11th September, 1886.

This able geologist and palæontologist was son of the late William Holl, Esq., formerly of Worcester. After passing through Dr. Walter's School at Worcester, he entered the Medical College in Birmingham.

During this period of Harvey Holl's career, when he was only about 17 years of age, he became acquainted with Sir Henry de la Beche, and was invited by that distinguished geologist to accompany him in a geological reconnaissance through Devon and Cornwall. It was probably owing to this expedition (which extended over some six months) that young Holl became confirmed in his geological tastes, and for a time was led entirely to abandon his medical studies.

From the good opinion which Sir Henry de la Beche formed of Holl's work in the field, he recommended the youthful geologist to his friend Professor Rogers, of Philadelphia (who was seeking an assistant), and Harvey Holl started off to join his new chief and take a part in the Geological Survey of Pennsylvania. In this interesting region, Holl remained for about three years, and spent a year longer in the United States geologising on his own resources.

Upon his return to England, Holl entered as a student at St. George's Hospital, and successfully passed the Royal College of Surgeons in London. In 1859 he graduated as M.D. at King's College, Aberdeen.

On the breaking out of the Crimean War, Dr. Holl was appointed one of the Senior Civil Surgeons to aid the military staff, which was totally inadequate to the heavy strain laid upon it by the first year's severe trials and sufferings. He remained abroad until the end of the campaign, serving partly in the Crimea, but most of the time in the hospital at Scutari. On his return after the conclusion of peace with Russia, he settled for some years as a medical practitioner in St. George's Square, Pimlico.

Dr. Holl was remarkable for his extremely reserved and retiring habits and formed consequently but few friendships. Yet he was by no means a man of small ability. As a medical practitioner he might have attained great eminence, but he never was ambitious of fame.

An earnest student of Cryptogamic Botany, he has left some forty-seven volumes of carefully collected British Lichens, all arranged and named by himself. He was also a liberal donor to the Botanical Department of the British Museum.

As a geologist and palæontologist, he displayed great power, and his papers always met with high appreciation in the Geological Society. During his field-excursions he had formed a considerable collection of British fossils, among which were numerous species and varieties of the Silurian genera *Beyrichia*, *Primitia*, and their allies, in very perfect preservation. As a good microscopist, clever draughtsman, and careful observer, he willingly and ably co-operated with Professor Rupert Jones in the study and description of the older Ostracoda. Within this year even he warmly assisted in the work, and notwithstanding his declining health, he supplied new sketches and notes of his favourite little fossils.

Dr. Holl was well known among the leading members of the Hereford, Woolhope, Malvern, and Cotteswold Natural History Field Clubs, and was himself frequently present at their meetings and excursions.

Although an excellent palæontologist, he will probably be most widely known and remembered as an able and experienced geologist, and the papers which will best be recollected are those on the Geological Structure of the Malvern Hills, in which area he made great advances on the work of Prof. Phillips; and his memoir "On the Older Rocks of South Devon and East Cornwall," in which he exemplified the excellence in method of his early teacher in Devonian geology, Sir Henry de la Beche.

To those who had the pleasure to know him, and were able to penetrate beneath his ordinary reserve, he will be remembered as a genial and pleasant comrade, full of scientific information, and lasting in his attachment to his friends.

Dr. Holl was elected a Fellow of the Geological Society in 1862, and having about this time relinquished his practice, he removed to Tower Lodge, The Link, Malvern, where he again took up his favourite geological studies, and in 1863 communicated a paper to the British Association "On the Metamorphic Rocks of the Malvern Hills."[1]

[1] Brit. Assoc. Report, 1863 (part 2), pp. 70—73.

In the same year he also read a paper before the Geological Society of London, "On the Correlation of the several Subdivisions of the Inferior Oolite in the Middle and South of England."[1]

From Malvern Dr. Holl removed to Elderslie House, London Road, Worcester, and thence to Little Perdiswell, Worcester, where he resided until about the end of 1884, when, for the sake of his health, he removed to Cheltenham, living first at 3, Oriel Villas, and lastly at 1, Derby Villas where he died after three weeks' illness, resulting from heart disease.

Besides those already named, the following additional papers are credited to Dr. Holl, namely:—

3. On the Geological Structure of the Malvern Hills and adjacent District. Quart. Journ. Geol. Soc. 1864, vol. xx. p. 413, and vol. xxi. 1865, pp. 72-102. Phil. Mag. 1864, vol. xxviii. p. 243.
4. On the Pre-Cambrian Rocks of Central England. Brit. Assoc. Rep. 1865, vol. xxxv. (Sect.), pp. 59-62; Geol. Mag. 1865. Vol. II. pp. 563-565.
5. *Goniophyllum pyramidale*, Hisinger. Geol. Mag. 1866, Vol. III. pp. 430-431.
6. On the Geological Position of the Crystalline Rocks of the Malvern Hills. Woolhope Field Club Trans. 1866, pp. 273-274.
7. On the Older Rocks of South Devon and East Cornwall. Quart. Journ. Geol. Soc. 1868, vol. xxiv. pp. 400-454; Phil. Mag. 1868, vol. xxxvi. p. 158.
8. Notes on Fossil Sponges. Geol. Mag. 1872, Vol. IX. pp. 309-315, and 343-352.
9. The Epitheca in Fossil Sponges. Monthly Microsc. Journ. 1872, vol. viii. pp. 141-142.

He was also joint-author with Prof. T. Rupert Jones, F.R.S., of the following papers, viz.:—

1. Notes on the Palæozoic Bivalved Entomostraca. No. VI. Some Silurian Species (*Primitia*). Ann. and Mag. Nat. Hist. 1865, vol. xvi. pp. 414-425.
2. Notes on the Palæozoic Bivalved Entomostraca. No. VIII. Some Lower Silurian Species from the Chair of Kildare. *Op. cit.* 1868, pp. 54-62.
3. Notes on the Palæozoic Bivalved Entomostraca. No. IX. Some Silurian Species. *Op. cit.* 1869, pp. 211-229.
4. Notes on the Palæozoic Bivalved Entomostraca. No. XX. On the Genus *Beyrichia* and some New Species. *Op. cit.* 1886, pp. 337-363.
5. Notes on the Palæozoic Bivalved Entomostraca. No. XXI. On some Silurian Genera and Species. *Op. cit.* pp. 403-414.

MISCELLANEOUS.

Memorial to Dr. Thomas Davidson, LL.D., F.R.S.—Thursday was the first anniversary of the death of Dr. Thomas Davidson. The proposed memorial to his memory in the Brighton Museum will take the form of a life-sized medallion in marble, framed in alabaster. The work has been undertaken by Mr. T. Brock, A.R.A., through the kind offices of Mr. Edward Armitage, R.A., an old friend and former fellow Art student of Dr. Davidson's in the ateliers of Paul de la Roche. Mr. Armitage has contributed £20 to the "Davidson Memorial Fund," and his advice and assistance have been of great service to the Committee and Hon. Secretaries.—*Brighton Herald*, Oct. 16, 1886.

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[1] Quart. Journ. Geol. Soc. vol. xix. (1863), pp. 70—73.

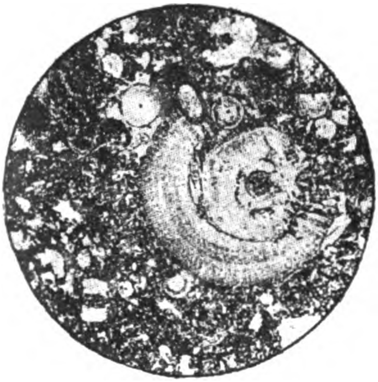

Fig 1. × 12 Diam.

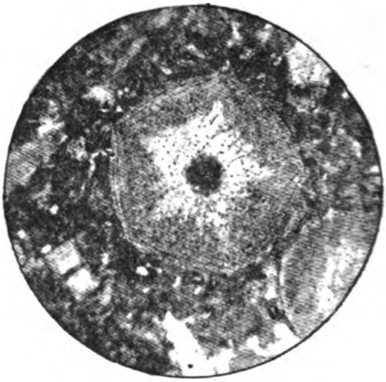

Fig. 2. × 22 Diam.

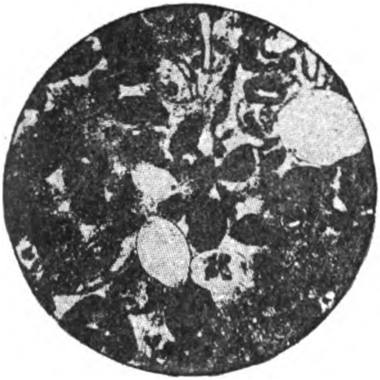

Fig. 3. × 22 Diam.

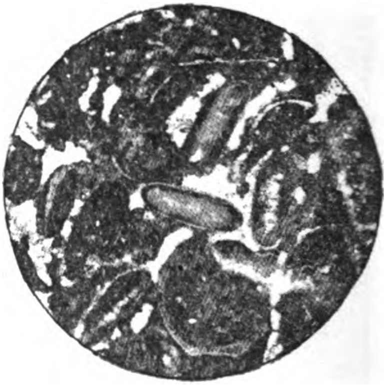

Fig. 4. × 22 Diam.

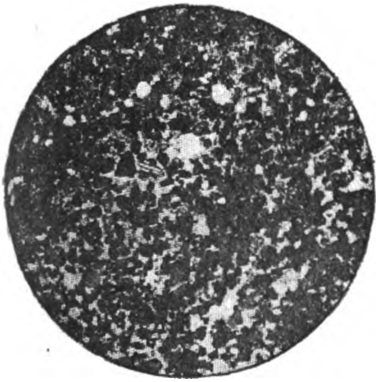

Fig. 5. × 22 Diam.

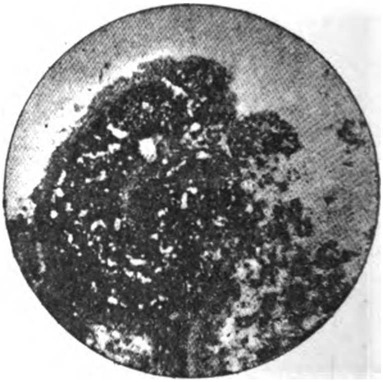

Fig. 6. × 12 Diam.

STRUCTURE AND ORGANISMS IN CARBONIFEROUS SHALES AND LIMESTONES,
FOREST OF DEAN.

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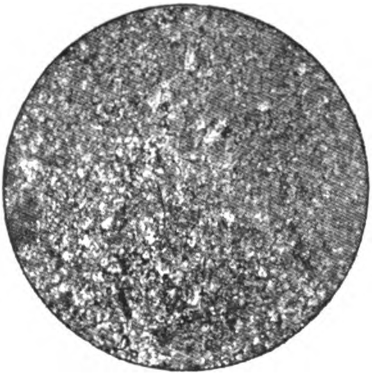

Fig. 7. × 22 Diam.

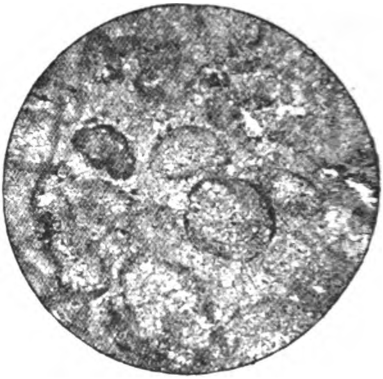

Fig. 8. × 22 Diam.

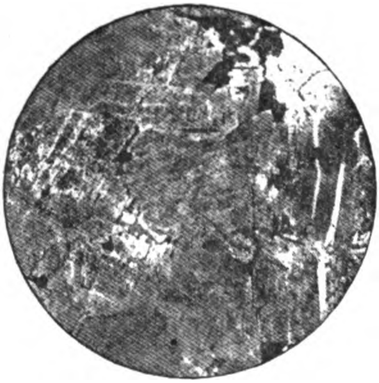

Fig. 9. × 22 Diam.

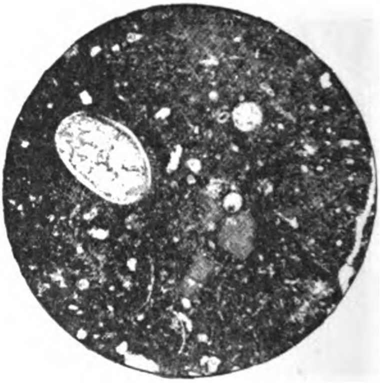

Fig. 10. × 22 Diam.

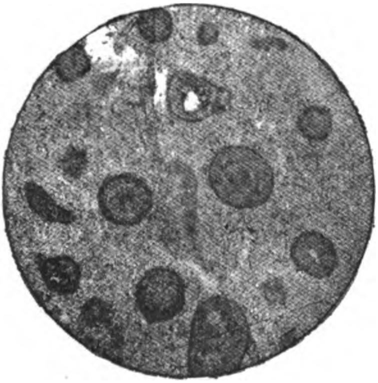

Fig. 11. × 24 Diam.

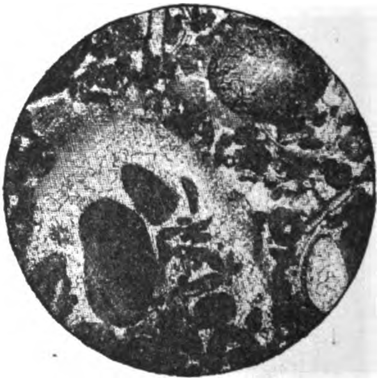

Fig. 12. × 22 Diam.

STRUCTURE AND ORGANISMS IN CARBONIFEROUS SHALES AND LIMESTONES,
FOREST OF DEAN.

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THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. III.

No. XII.—DECEMBER, 1886.

ORIGINAL ARTICLES.

I.—On the Structure and Organisms of the Lower Limestone Shales, Carboniferous Limestone and Upper Limestones of the Forest of Dean.

By Edward Wethered, F.G.S., F.C.S., F.R.M.S.

(PLATES XIV. & XV.)

SIR ANDREW RAMSAY has described[1] the Coal-fields of the Forest of Dean, Somersetshire, and Bristol as outliers of the great Coal-fields of South Wales; there is, however, a marked thinning out in the thickness of the Carboniferous rock in the Forest of Dean as compared with the development of those rocks in South Wales and Bristol. At Clifton, near Bristol, the total thickness of the Carboniferous Limestone is about 2900 feet, at the northern end ot the Forest of Dean Coal-field it is about 600 feet.

Professor Edward Hull has given[2] a comprehensive idea of the several divisions of the Carboniferous series as represented by typical developments in England. He has divided the series into three divisions, which he has again subdivided into *stages* marked by letters. The following is Professor Hull's classification, but I have omitted details which do not concern this paper.

The British Carboniferous Series. Beds in Descending Order.

Essentially Fresh-water and Estuarine Beds.	Stage G.	Upper Coal-Measures.
	Stage F.	Middle Coal-Measures.
Essentially Marine.	Stage E.	Gannister Beds (Phillips), or Lower Coal-measures.
	Stage D.	Millstone-grit Series. Coarse grits, flagstones, and shales, with a few thin coal-seams.
	Stage C.	Yoredale Series. Shales and grits, passing downwards into dark shales and earthy limestones.
Essentially Marine, except Stage A in Scotland.	Stage B.	Carboniferous Limestone. Massive Limstone, passing northwards into several beds, with intervening shales and grits.
	Stage A.	Lower Limestone Shales and Calciferous Sandstone. Dark shales in some places; grits, conglomerates, and red sandstones and shales in the northern district.
Freshwater Beds.	Base.	Upper Old Red Sandstone. Yellow sandstones and conglomerates.

In the Forest of Dean stage A is represented resting on a succession of many-coloured calciferous sandy beds and shales, very much like what Prof. Hull describes as occurring in "northern districts." They were first described by Mr. W. C. Lucy, F.G.S.,[1] and later on by myself.[2] Stage B is represented by the Carboniferous Limestone, or middle series, but appears to be quite void of fossil remains, which fact I shall refer to later on. Above stage B, Professor Hull gives, as stage C, the Yoredale Series, and he describes them as "shales and grits, passing downwards into dark shales and earthy limestones." In the Forest of Dean we have beds very similar in a lithological point of view to those which Prof. Hull described; but in my previous paper, just referred to, objection was taken to my classing these upper limestones as the representatives of the Yoredale Series. I shall not in this paper discuss that question, but I shall show that these upper limestones are different from the Carboniferous Limestone, and are quite as much entitled to be grouped separately as the Lower Limestone Shales. To condense what I have said, the Carboniferous Limestone series in the Forest of Dean consists of the following divisions:—

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[1] Physical Geology and Geography of Great Britain, fifth edition, pp. 34, 35. Also, Mem. Geol. Survey, vol. i. p. 303.

[2] Quart. Journ. Geol. Soc. vol. xxxiii. p. 615, 1877.

	Approximate thickness in feet.
Upper Limestones (occupying position of Yoredale Series of the North of England.) Stage C.	116[3]
Carboniferous Limestone proper. Stage B.	360
Lower Limestone Shales. Stage A.	130

LOWER LIMESTONE SHALES.

The calciferous sandy beds, which succeed Old Red Conglomerate, gradually become more calciferous in ascending order, till at last a series of quarries are found opened out in a succession of limestones and shales. Some of the latter are bituminous, a feature to which I have called attention in a paper communicated to the Cotteswold Club.[4] The lowest of these beds are exposed in two quarries on either side of the deep cutting near Drybrook, from which the following specimens were selected (see Plates XIV. and XV.).

No. 1 (Plate XIV. Fig. 1).—A crinoidal limestone which gave the following result on chemical analysis:—

Insoluble in acid	Insoluble residue (Sand)	3·68
	Organic matter	3·30
Soluble in acid	Carbonate of Lime...	90·40
	Carbonate of Magnesia	2·38
	Carbonate of Iron...	·42
	Alkalies	trace
		100·18

The sand is little else than grains of quartz as large as ·01 of an inch in diameter, but average about ·003. The larger ones are rounded, the smaller ones angular. The absence of alumina in the analysis is a feature to be noticed, as in the analysis of a crinoidal limestone from the Lower Limestone Shales from Clifton the late Mr. Stoddart also called attention to the absence of alumina: he remarks,[1] "The absence of alumina in these beds is very remarkable, because the Lower Limestone Shales are very argillaceous." The organic remains preserved in this bed are chiefly those of Crinoids, associated with Polyzoa, the spines of *Spirifera* and *Productus*; in some layers the two latter are very numerous.

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[1] Proc. Cotteswold Club, 1866.

[2] Quart. Journ. Geol. Soc. vol. xxxix. p. 212, 1883.

[3] I put the Upper Limestone at 116 feet, but it is impossible to measure the thickness accurately at present. The Wilderness Portland Cement Company, however, is making a cutting, near Mitcheldean, with the object of ascertaining the thickness, as the limestone produces a good cement.

[4] "On the Occurrence of Spores of Plants in the Lower Limestone Shales of the Forest of Dean," Proc. Cotteswold Club, 1883—1884, pp. 168—173.

No. 2.—A light blue hard compact limestone, almost entirely made up of the valves of Ostracoda, but there are also present a few Polyzoa, the spines of Brachiopoda, and *Spirorbis carbonarius*. In the majority of cases the valves of the Ostracods are broken into fragments, but where preserved the largest measure ·035 of an inch in diameter. The remains are cemented together by crystalline calcite, and the empty valves are also filled with the same mineral.

No. 3.—A slightly ferruginous limestone. The organic remains are not well preserved; those which can be determined consist of joints of Crinoids, remains of Polyzoa, valves of Ostracods and obscure calcareous fragments.

No. 4.—A dark argillaceous bed containing 17·15 per cent. of organic matter, 6·89 of which was volatile. On washing a sample with distilled water, a large quantity of mud is got rid of, and the residue consists of quartz-grains, fragments of shells, plant-remains, and the jaws of Annelides.

No. 5.—A concretionary limestone slightly oolitic, the nuclei of the granules are grains of quartz. There are also present the valves of Ostracods, joints of Crinoids, and the remains of a small Coral.

The next specimens were selected from a quarry a little beyond the last in the direction of Mitcheldean, in which beds were exposed occupying a higher horizon than those in the previous quarry.

No. 6.—From a thickness of about 10 feet of thin strata, slightly ferruginous; on exposure to the air, the carbonate of iron (in which state the iron exists) undergoes decomposition, ferric oxide is formed which imparts a yellow tinge to the rock. The structure exhibited is chiefly that of calcareous sand, among the grains of which are fragments of shells. The spaces between the sand are filled in with calcite.

No. 7 (Pl. XIV. Fig. 3).—A bed of argillaceous limestone 3½ inches thick, and contains 11·15 of sand. It is made up of the valves of Ostracods, occasionally Polyzoa, scanty fragments of Crinoids, and oolitic granules. As in the previous examples, the limestone is consolidated by an infilling of calcite.

No. 8.—A dark argillaceous limestone 8½ inches thick, and containing 16·4 per cent. of sand. The calcareous constituents comprise the spines of *Spirifera*, broken valves of Ostracods, and other remains which are too obscure to be determined; some were probably decomposed and altered shell fragments.

No. 9.—Light brown arenaceous limestone, 6 inches thick, containing 37·2 per cent. of sand in quartz grains, measuring ·004 of an inch in diameter. Microscopic sections show the valves of Ostracods, numerous spines of *Spirifera*, fragments of shells, etc. The vacant spaces are filled in with calcite.

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[1] Ann. Mag. Nat. Hist. vol. viii. 3rd series, p. 487.

No. 10.—A bed of blue argillaceous limestone 6 inches thick; contains 16·75 per cent. of sand, the grains of which are rounded and measure about ·004 of an inch in diameter. The rock is chiefly made up of the spines and other remains of Brachiopoda and numerous valves of Ostracods.

No. 11.—A black argillaceous bed 5½ inches thick with calcareous arenaceous layers. In the argillaceous material the joints of Crinoids, remains of a small variety of *Rhynchonella pleurodon* and Ostracods were discovered. Sections of the thin calcareous layers showed them to be largely made up of the spines of *Spirifera*, a few joints of Crinoids, and calcareous fragments.

No. 12.—An earthy limestone 5 inches thick; contains 12 per cent. of sand, the grains of variable size, the largest measuring ·008 and the smallest ·002 of an inch in diameter. The limestone is largely made up of an organism to which I shall provisionally give the name of *Mitcheldeania* (Pl. XIV. Fig. 6), and which I shall describe further on. The rock also contains some Ostracoda.

No. 13 (Pl. XIV. Fig. 4).—A light limestone 8 inches thick, containing 3·2 per cent. of sand, the grains measuring ·003 of an inch in diameter. Flakes of mica and fragments of other minerals are also present. The bed contains the remains of *Mitcheldeania*, a few Polyzoa, a large proportion of Ostracoda, and a shell which Mr. Etheridge, F.R.S., tells me is allied to *Murchisonia angulata*.

Pl. XIV. Fig. 4 represents a portion of the rock in which the valves of Ostracods are the chief feature. The clear calcite is well shown filling up the empty valves and spaces between them.

No. 14.—Similar to the last, with the exception that *Mitcheldeania* is less numerous. Thickness 1 foot 6 inches.

No. 15 (Pl. XIV. Fig. 5).—Made up of various small concretions, of various shapes; calcareous fragments and occasional spines of *Spirifera*. Thickness 2½ inches.

No. 16.—A limestone 1 foot 3 inches thick. Chiefly concretionary, with the spines of *Productus*, Crinoidal remains, and other calcareous fragments.

No. 17.—A black argillaceous bed 4 inches thick, containing 5·13 per cent. of sand, the quartz grains measuring ·004 of an inch in diameter. Flakes of mica and fragments of other minerals also present.

No 18.—A light argillaceous limestone 7 inches thick, containing 16·5 per cent. of sand, the quartz-grains varying between ·009 and ·001 of an inch in diameter. The organic remains are chiefly those of Ostracods, well preserved and capable of being extracted from the matrix.

No. 19.—A shelly limestone 15 feet thick, and containing 39·2 per cent. of sand. The chief calcareous constituents are the remains of shells, and those in a very fragmentary condition.

General Review of the Lower Limestone Shales.

The samples examined are sufficient to give a correct idea of the structure of the rock generally. In the lowest beds of the series Ostracods have contributed very largely, in some cases little else than the valves of these small Crustaceans make up the limestone. In the upper beds, with the exception of No. 16, they become less numerous, and in some cases are altogether absent.

Much the same may be said of the Crinoids. Though their remains occur throughout the series, they are most numerous in the lowest beds, and in one they are the chief factor, as in Fig. 1. The Polyzoa are most numerous in the Crinoidal bed, but are to be found throughout the Lower Limestone Shales. They are not, however, an important feature in the structure of the rocks with the exception stated. The shells of *Rhynchonella pleurodon* are very numerous in some beds of black shale, and on weathering taking place, they may be collected in hundreds. The Lower Limestone shales, as with limestones generally, represent the floor of a sea in which the organisms lived which we now find in a fossil state. By their death the limestone was formed from the calcareous portions of their structure. The deposition of the strata doubtless extended over a long period of time, during which the conditions were varied, and thus the life varied according as the conditions suited. For this reason we get limestones of different structure and quality, which, of course, was regulated by the organisms which contributed to their formation. The limestone-forming process was at times stayed, during which intervals clays and shales were deposited. The water was probably not deep. This is shown by the amount of sand in the limestone, and also by the great profusion of Ostracods, which class of Crustacea are not abundant in extreme depths of water.[1]

ORGANISMS OF THE LOWER LIMESTONE SHALES.

Ostracoda.—My specimens have been referred to Professor Rupert Jones, F.R.S., and Mr. J. W. Kirkby, to whom I am indebted for their careful examination. The following is a list of the genera and species which these gentlemen have been able to determine. Probably others exist, but the difficulty of separating them from the matrix, and thus obtaining reliable specimens, prevents a more definite statement being made.

Kirkbya variabilis, J. & K.
,, *plicata*, J. & K.
Cytherella extuberata, J. & K.
Bythocypris sublunata, J. & K.
Darwinula Berniciana (?), Jones.
Leperditia Okeni, Munster.

The above list is especially interesting and important in connection with the Ostracoda recently described[2] by Prof. Jones and Mr. Kirkby from the Gayton boring, Northamptonshire. The material examined yielded six recognizable forms, as follows:—

Kirkbya variabilis, J. & K.
,, *plicata*, J. & K.
Bythocypris sublunata, J. & K.
Macrocypris Jonesiana (?), K.
Cytherella extuberata, J. & K.
,, *attenuata*, J. & K.

Comparing the above list with mine, from the Forest of Dean, we find that from the Gayton boring six genera and species were determined, one of which was doubtful. In my list six genera and species are also given, one of which, too, is doubtful. In each case we get five undoubted genera and species, and of these four appear in both lists. Mr. Kirkby writing to me remarks: "It is surprising how similar the groups of species are to those we have just described from the Gayton boring."

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[1] Challenger Report, Zoology, on the Ostracoda, p. 1.
[2] GEOL. MAG. 1886, Dec. III. Vol. III. pp. 248—253.

Professor Jones, after an examination of different samples from the same locality, makes similar remarks. Of the forms described from the Gayton boring three have not been known to occur above the Calciferous series of Scotland, which horizon is immediately above the Old Red Sandstone (Devonian). The forms referred to are *B. sublunata*, *C. extuberata*, and *C. attenuata*. Of these two appear in my list.

Crinoidea.—The Crinoidal remains in the Lower Limestone Shales appear to be those of two genera. One of these is *Poteriocrinus crassus*, Miller, and the other probably Miller's genus *Rhodocrinus*. In some of my slides apparent pentagonal joints are seen (Pl. XIV. Fig 2), which I was at first puzzled to account for. On reference to Miller's "Crinoidea," I found that he had figured[1] joints resembling mine, which were also collected in the Forest of Dean, and that he referred them to *Rhodocrinus verus*. Miller in his "Description" expresses some doubt as to whether all the forms referred by him to this genus are really the same species; he remarks: "In the columns (pl. ii. fig. 1, t. 22) which I consider as belonging to the animal of this genus, I have noticed two different modes of organization, which inclines me to suspect that although I am only able to treat of one species as decidedly ascertained, yet two distinct species may really exist. Thus in regard to the surface of adhesion, some columnar joints display numerous radiating striæ proceeding immediately from the alimentary canal to the circumference (figs. 6 to 10); other joints (figs. 1 to 5) have only a narrow striated rim with a smooth central area; and again some columns (figs. 11 to 15) are formed of joints of uniform thickness, from some of which, occasionally, several side-arms proceed; whilst other columns, particularly those from Mitcheldean, are formed of joints alternately thicker and thinner, smaller and larger, much contracted at their margin of mutual adhesion. In these every second or fourth joint is considerably thicker, showing at its circumference five or six tubercles, which render it angular and its surface waved, to which the joints above and below conform." It is therefore clear that Miller detected some points of difference in the specimens from the Forest of Dean compared with those from other localities. With regard to the striæ, I think he attaches too much importance to them; they are simply striations on the articular faces of the stem-joints, and the features pointed out by Miller are due to the particular portion preserved or examined. With regard to the joints themselves, these are features which are of importance, and though Miller only considered them of sufficient note to possibly justify a different species, it is probable that further investigation may prove that the fossil is wrongly referred to the genus *Rhodocrinus*. Having doubts regarding the specimens which I had collected, I sent them to Dr. P. Herbert Carpenter, F.R.S., and asked his opinion on them. He kindly wrote me as follows: "I think your pentagonal stem-joints may not improbably be identical with those figured by Miller on plate 2 of *Rhodocrinus*, figs. 17–22, but I have great doubts whether they can be properly referred to *Rhodocrinus*."

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[1] "Miller's Crinoidea," 1821, *Rhodocrinites*, plate 2, figs. 17, 18, 19, p. 107.

The microscopic section shown in Fig. 1 appears to throw some light upon the apparent pentagonal joints. The central object represents one of them surrounded by a circular margin. It is therefore possible that some of these Crinoids have a pentagonal centre, and that it is this central portion which is represented on Pl. XV. Fig. 12. I have shown my specimens to Mr. R. Etheridge, jun., who informs me that he has observed the same thing in some Crinoids which have come under his notice.

POLYZOA.—The specimens of Polyzoa were sent to Mr. John Young, Curator of the Hunterian Museum, Glasgow, who kindly examined them for me. Though the Polyzoa occur in such large numbers in the crinoidal bed, Mr. Young has only been able to detect two genera and species, namely, *Rhabdomeson* (*Millepora*) *gracile* (Phill.), and *Fenestella tuberculocarinata* (Etheridge, jun.).

MITCHELDEANIA NICHOLSONI, gen. et. sp. nov. (Plate XIV. Fig. 6).—I have referred the specimens of this organism to Mr. John Young, Dr. Hinde, Professor Nicholson of Aberdeen, and to Mr. Robert Etheridge, jun., all of whom have kindly examined them, but are unable to recognize them as identical with any known form. I have, therefore, determined to describe and figure it as a new provisional genus under the name of *Mitcheldeania*, after the locality (Mitcheldean) near which I found it. To Professor Nicholson I am especially indebted for assistance in examining the fossil, but he is in no way committed to any of my remarks in reference to it. As a slight acknowledgment of Professor Nicholson's assistance and appreciation of his work generally, I propose to name the first species of the genus *Nicholsoni*. In working out this organism I have been placed at a disadvantage in not being able to separate reliable specimens from the matrix, on account of the nature of the rock in which the fossil occurs; the determination, therefore, has been chiefly arrived at from microscopic slides.

The organism, Fig. 6, consists of a series of concentrically arranged layers, or laminæ, penetrated by systems of tubuli which become more minute and numerous in the central series of laminæ. The tubuli are separated by the skeleton fibre, which is itself penetrated by a minute canal system. There are also other tubuli of larger size than are seen in the inner laminæ, which appear first in the third series, and become more numerous outwards. The skeleton fibre is also penetrated, in places, by centres of growth made up of concentrically arranged minute tubuli, resembling the series which constitute the nucleus of the entire organism. At the base there is a peduncle which probably served for attachment.

CONCLUSIONS.—*Mitcheldeania Nicholsoni*, then, was an organism the structure of which consisted of a series of concentrically arranged layers penetrated by two systems of tubuli, the larger measuring ·003 and the smaller ·001 of an inch in diameter. The latter were probably filled with living matter, and the larger I regard as zoöidal tubes. I would refer this organism to the Hydractinidæ, and as allied to the Stromatoporoids. Professor Nicholson is himself struck with the similarity of the structure to certain Stromatoporoids, but remarks that he is not aware of any which have so minute a canal system of precisely the same nature; and that if it be referable to the Stromatoporoids, it would probably require to be placed in a new genus. Of course I am aware that Stromatoporoids have not before been noticed in Carboniferous rocks, but that is no reason why they should not occur.

In referring *Mitcheldeania Nicholsoni* to the Stromatoporoids, I do not wish to ignore certain features which this fossil possesses in common with some other Hydrozoa. Professor Nicholson called my attention to *Parkeria*, Carp., which no doubt shows structure which is also seen in *M. Nicholsoni*, but in the former there is a nucleus constituted of chambers which are laid end to end in a reticulate direction, and separated by septa. I have not detected a nucleus of this nature in *M. Nicholsoni.*

Another organism which especially struck Dr. Hinde as similar to my new genus is *Girvanella problematica*, Nich. and Ether., jun. Professor Nicholson has kindly sent me rock specimens containing that fossil, from which I have been enabled to get some good sections. As regards mode of occurrence, there is a great resemblance, and also in the concentric lamination, but the minute structure is quite different.

THE CARBONIFEROUS LIMESTONE—or Stage B of Prof. Hull—constitutes the middle division of the limestone series in the Forest of Dean. Commencing with the lowest beds, I have worked upwards, and in all that I have examined, the slides exhibit the same structure, namely, a rock made up apparently of very small calcareous granules (Pl. XV. Fig. 7). It is not, however, so formed; the key to the problem is Pl. XV. Fig. 8, in which we see the outlines of a previous structure, the whole having undergone complete change and been replaced by crystalline material. The granular appearance is due to the small crystals and possibly large ones which have cracked or split up into fragments. As to what the replacing mineral is, the following chemical analysis will enable us to judge. The sample was taken from the centre of the formation, and though one analysis cannot be said to prove the composition of the whole 360 feet of strata, yet I believe it to be typical of at least a large portion.

In making the analysis I was assisted by Mr. W. E. Wiltshire, F.C.S. As it is important, I will state it in two forms:

I.		II.	
Moisture	·02	Moisture...	·02
Organic matter...	6·17	Organic matter	6·17
Carbonic acid	44·01	Insoluble Residue	1·06
Insoluble Residue	1·06	Carbonate of Iron	1·01
Soluble Silica	·10	Soluble Silica	·10
Ferrous Oxide	·63	Carbonate of Lime	54·00
Lime	30·24	Carbonate of Magnesia... ...	37·19
Magnesia	17·50	Carbonate of Soda with trace of chlorine	·43
Soda	·25		
	99·98		99·98

The foregoing analysis shows the limestone to be dolomitized, the carbonate of magnesia being as high as 37 per cent. Of this I shall treat further under the head of chemistry.

THE UPPER LIMESTONE SERIES.

This series consists of two varieties of limestone locally termed the "Crease" and "Whitehead." The former occupies the lower horizon of the two.

The Crease (Pl. XV. Fig. 9).—The samples which I have examined show an unusually coarse structure due to the size of the calcareous fragments of which the limestone is made up. The origin of these calcareous fragments is somewhat obscure, but I have detected among them undoubted remains of Crinoids. The grains are closely compressed, reminding one of the structure of arenaceous grits; the rock is, indeed, a calcareous grit.

The "Whitehead" Limestone.—The "Whitehead" follows the "Crease," and is represented by an interesting series of beds from which I have selected the following as typical.

No. 1 (Pl. XV. Fig. 11).—Oolitic limestone, from a thickness of about forty feet. The granules measuring from ·007 to ·018 of an inch in diameter. The nuclei are generally destroyed, leaving an open space. The spaces between the granules are often wide and are filled with calcite.

No. 2.—A concretionary limestone from a bed three feet thick. Contains the valves of Ostracoda, spines of *Productus* and angular grains of quartz. There are also present circular rings as large as ·005 of an inch in diameter, and are a conspicuous feature in the rock.

No. 3.—From a bed made up of concretionary nodules, as large as an inch in diameter, and calcareous sand. Microscopic sections of the nodules reveal the remains of a variety of organisms, but all badly preserved.

No. 4.—This is a very interesting bed, and makes a beautiful object under the microscope (Pl. XV. Fig. 12). The rock is made up of the remains of a spiral shell, of Foraminifera, Ostracoda, Polyzoa, and obscure calcareous fragments, the whole being cemented together by clear calcite.

No. 5 (Pl. XV. Fig. 10).—A peculiarly white limestone, which gave the following analysis:—

Insoluble residue (sand)	2.95
Organic matter	6·94
Water	1·40
Carbonate of Lime	85·56
Carbonate of Iron	·46
Soluble Silica	·01
Carbonate of Magnesia	·84
Alkalies	1·06
Phosphate and Sulphate of Lime, and loss	·78
	100·00

Sections of the limestone show it to be largely made up of the remains of Ostracoda, among which Professor Jones has distinguished *Leperditia* and *Cytherella*, but as we have not been able to separate any from the matrix, the species have not been determined. In addition to Ostracoda, the rock contains remains of Foraminifera badly preserved, also occasional Polyzoa, and the spines (and possible shell fragments) of *Productus.*

GENERAL VIEW OF THE UPPER LIMESTONES.

The beds of the Upper Limestones indicate a return of conditions not unlike those which existed at the time of the deposition of the Lower Limestone Shales. At the period of the latter, the Carboniferous Limestone was about to commence; at the period of the former, it was near to its close, and the great Coal epoch was soon to dawn. From what I have said respecting the changes which the beds of stage B, or the Carboniferous Limestone proper, have undergone, it is difficult to say what fossils they contained or what organisms contributed to the formation of the limestone; but in the Upper Limestones we get a return of life similar to that which contributed so largely to the Lower Limestones. I therefore contend that I am justified in forming a separate division of the Upper Limestones. If I am not, then there is no justification for making a separate division of the Lower Limestone Shales.

CHEMISTRY.

As in the case of limestones generally, the Lower and Upper series have been consolidated by the deposition of calcite in the vacant spaces between the organisms and other calcareous fragments. With regard to the Carboniferous Limestone, that, too, undoubtedly originated from calcareous organisms, but a subsequent change occurred which replaced the original structure with magnesia and possibly some calcite. I am not aware that dolomitization in the Carboniferous rocks of the Forest of Dean has before been noticed, but it has in other localities. Mr. Sorby, F.R.S., states[1] that "in Derbyshire and elsewhere some of the beds are almost pure dolomite. As far as can be judged from their structure, they may have been normal limestones completely changed after deposition, and certainly do enclose dolomitized shells, Corals, and Encrinites." The late Professor Harkness called attention to the same thing in a paper[2] "On the Jointing in the Carboniferous and Devonian Rocks in the district around Cork and on the Dolomite of the same district." The limestone referred to by Professor Harkness has undergone considerable jointing, which he considered to be a factor in the process by which those particular beds became dolomitized. He says:[3] "The whole aspect of the Carboniferous dolomites of Cork and Kilkenny leads to the inference that certain changes have been effected on previously existing masses of carbonate of lime; and the general parallelism which occurs between these dolomites and the main joints, and also the intimate connexion which exists between them, supports the conclusion that the change was produced after the operation of those forces which gave rise to the phenomena of joints." Professor Harkness attributes the dolomitization to the sea-water finding its way into the joints and fissures of the limestone when submerged. In the case of the Forest of Dean, however, the amount of jointing would not be sufficient to produce such effects, in the presence of sea-water, as Professor Harkness speaks of in the district of Cork. That sea-water was the agent which supplied the magnesia I do not agree. Professor J. D. Dana states[1] that "analyses of the Coral Limestone of the elevated coral island Matea, by Professor B. Silliman, jun., have determined the singular fact that, although the Corals themselves contain very little carbonate of magnesia, magnesia is largely present in some specimens of the rock. It affords on analysis, 38·07 per cent. of carbonate of magnesia, and hence only 61·93 of carbonate of lime. . . . This introduction of magnesia into the consolidating submerged coral-sand or mud, has apparently taken place (1) in sea-water at the ordinary temperature; and (2) without the agency of any mineral waters except the ocean. But the sand or mud may have been that of a contracting and evaporating lagoon, in which the magnesia and other salts of the ocean were in a concentrated state." Looking at the fact that the Carboniferous Limestone in the Forest of Dean was undoubtedly originally formed by accumulations of the remains of organisms, seems to me to be against the lagoon theory. Had the strata been deposited under conditions of concentrating waters, I fail to see how the organisms could have lived in so briny a solution. In endeavouring to arrive at a solution of the problem, there are two details which must be considered. (1) The beds of the Carboniferous Limestone are not mixed with argillaceous strata; those of the Lower and Upper Limestone series are. (2) The proportion of insoluble residue (sand) in the Carboniferous Limestone is small. These two facts seem to indicate that either there was deep water at a distance from land, too far for much sediment to be carried, or else a lagoon existed. My objection to the lagoon theory has already been stated, and I think the evidence is in favour of deep water some distance from land. But in what way would this solve the problem of the formation of dolomite in the Carboniferous Limestone? We must consider the fact that in the Lower and Upper Limestones there are argillaceous beds; these latter are less numerous in the former than in the latter, and I am informed by Colchester Wemyss, Esq., J.P., that some of the beds contain a considerable proportion of magnesia. The effect of these argillaceous beds, it seems to me, would be to cover the limestone beneath with a water-tight stratum. This, however, was not so in the Carboniferous Limestone, and consequently the sea-water would have free course through the at first loosely accumulated calcareous remains. That dolomite might, under such circumstances, result from the decomposition of magnesium chloride, and possibly magnesium sulphate, we can readily understand. That dolomite can be produced by the decomposition of magnesian chloride in the presence of Iceland spar has been proved by Mr. Sorby, F.R.S.[1]

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[1] Quart. Journ. Geol. Soc. Proc. 1879, vol. xxxv. p. 87.
[2] Quart. Journ. Geol. Soc. vol. xv. p. 86.
[3] Quart. Journ. Geol. Soc. vol. xv. p. 103.

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[1] Corals and Coral Islands, 1872, pp. 356—357.

EXPLANATION OF PLATE XIV.

Fig. 1. Crinoidal Limestone, Lower Limestone Shales.
,, 2. Apparent pentagonal stem joint of a Crinoid, from the same bed as Fig. 1.
,, 3. Lower Limestone Shales, contains remains of Ostracoda, occasional Polyzoa, &c.
,, 4. Lower Limestone Shales, chiefly made up of the remains of Ostracoda. The infilling calcite in the spaces between the organisms is well illustrated in this specimen.
,, 5. Lower Limestone Shales, chiefly made up of minute calcareous fragments and concretions.
,, 6. *Mitcheldeania Nicholsoni.*

PLATE XV.

Fig. 7. Dolomitized Carboniferous Limestone.
,, 8. Dolomitized Carboniferous Limestone, the outlines of previous structure remaining.
,, 9. "Crease Limestone," base of Upper Limestone Series.
,, 10. "Whitehead Limestone," Upper Limestone Series, showing remains of Ostracoda and Polyzoa.
,, 11. Oolitic Limestone, Upper Limestone Series.
,, 12. Whitehead Limestone, another bed, showing remains of Ostracoda, spines of *Productus*, etc.

II.—On the Rocks surrounding the Warwickshire Coal-field, and on the Base of the Coal-measures.[2]

By Aubrey Strahan, M.A., F.G.S.,
H. M. Geological Survey.

With Appendix I. on the Igneous Rocks of the Neighbourhood, by Frank Rutley, F.G.S. Appendix II. on the New Species *Olenus Nuneatonensis* and *Obolella granulata*, by G. Sharman.

(Communicated by permission of the Director-General.)

In a paper read before the Birmingham Philosophical Society in 1882, it was announced by Professor Lapworth that the discovery of fossils in some shales underlying the productive Coal-measures of Warwickshire, and coloured on the Geological Survey Map as Coal-measures, proved that these shales must be of Cambrian age (Lower Silurian of the Geological Survey).[3] As the true age of these shales had for many years been a debateable question, Professor Lapworth's discovery was of considerable interest, and has led to an important alteration being made in the map, the supposed Lower Coal-measures and Millstone Grit having both been now relegated to the Lower Silurian (Lingula Flags). It may be of interest, before entering on the description of these beds, to trace shortly the history of the error in their classification.

The first notice referring to the older rocks of Warwickshire that appeared in the publications of the Geological Society is a paper on the occurrence of manganese near Hartshill.[1] The ore is described as occurring in detached pieces weighing from one to sixty pounds each, and distributed through a red clay, which chiefly forms the soil of the neighbourhood.

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[1] Quart. Journ. Geol. Soc. Proc. 1879, vol. xxxv. p. 73.

[2] Read before Section C. (Geology), British Association, Birmingham, Sept. 2, 1886.

[3] The nomenclature of the Geological Survey, according to which the Lingula Flags are included in the Lower Silurian, will be used throughout this paper.

In 1822 the rocks in which the ore occurred were referred to as Coal-shale and Millstone Grit by Conybeare and Phillips.[2] In 1829 the Rev. James Yates[3] pointed out the resemblance of the Hartshill quartzite to that of Bromsgrove Lickey, and gave a most accurate account of the overlying shales and the intrusive character of the volcanic rocks, concluding that the quartzite and shales must be considered of Silurian age. In 1855 the Geological Survey Map (63 S.W.) was published, and was followed in 1859 by the Memoir on the Geology of the Warwickshire Coal-field, Sir R. Murchison being Director-General. In these publications the quartzite was referred to the Millstone Grit, and the overlying shales to a lower or unproductive subdivision of the Coal-measures. The reasons for which this classification was adopted are given on p. 8 of the Memoir. The quartzite "has an average dip to the south-west at an angle of from 30° to 40°, passing under the ordinary Coal-measures which lie conformably upon it. No fossils have ever been found in it, and from the strong resemblance it bears to the quartz-rock of Bromsgrove Lickey, it was formerly classed as part of the Silurian series; but from the fact of the complete conformity of the Coal-measures upon it, and the occasional streaks of Coal-measure-looking shale with which it is banded, the evidence is more in favour of its belonging to the Carboniferous formation." This conclusion was not arrived at without anxious deliberation. The late Prof. Jukes and Mr. Howell were in favour of retaining the beds in the Silurian series, while Sir A. Ramsay (at that time Local Director), in consideration of the perfect conformity between the quartzite and overlying shales, and of the *apparent* conformity between the shales and the productive Coal-measures, was of opinion that they must be included in the Carboniferous series. The views of Prof. Jukes are given in the Memoir on the South Staffordshire Coal-field (Memoirs of the Geological Survey), 2nd edition, 1859, p. 134. After speaking of the gentle westerly dip which the Silurian strata of the South Staffordshire Coal-field had assumed before the deposition of the Coal-measures, he continues: "That this gradual rise to the east was continued yet further in that direction beyond the bounds of our district is rendered probable by the fact of rocks still older than the Upper Silurian (perhaps older than any Silurian) appearing in the Warwickshire and Leicestershire coal-fields, with the Coal-measures resting directly upon them." Previously (pp. 80, 81, fig. 11), he had figured and described a section near Dudley, in which the Coal-measures were seen resting on Silurian shale, both being nearly horizontal, but the unconformity being shown by the fact of the Coal-measures abutting against a small cliff of Silurian shale at one part of the section. "From this very instructive instance we learn generally how, with perfect apparent local conformability, there may be still on the large scale a very great amount of unconformability between two formations." From these statements it is quite clear that Prof. Jukes had fully grasped the true relation borne by the Warwickshire quartzite and shales to the overlying Coal-measures.

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[1] Notice on the Black Oxide of Manganese of Warwickshire, by S. Parkes, Trans. Geol. Soc. series 2, vol. i. p. 168, 1824 (read 1821).

[2] Outlines of the Geology of England and Wales, by the Rev. W. D. Conybeare and W. Phillips, book iii. chap. iii. p. 406, and chap. v. p. 456.

[3] On the Structure of the Border Country of Salop and North Wales, etc., Trans. Geol. Soc. series 2, vol. ii. p. 237, 1829 (read in 1824).

In 1879, the results of a microscopic examination of the intrusive Diorites were described by Mr. Allport,[1] who accepted the conclusion of the Carboniferous age of the rocks, and it was not until the year 1882 that the discovery of fossils in the shales by Prof. Lapworth[2] finally disposed of the possibility of the beds being of Carboniferous age, and established the correctness of the earlier view that the quartzites with the overlying shales were of Silurian age. This being the case, it was evident that the base of the Coal-measures had yet to be found, and traced upon the map, and for the purpose of doing this I received instructions to proceed to the district in the spring of this year.

This task was rendered far easier than it would otherwise have been by Professor Lapworth's kindness in placing freely before me the results of his own observations on the Silurian rocks, and on their relations to a still older volcanic series beneath, one of the most valuable of these results being his discovery of fossils at different horizons, ranging from near the top to near the bottom of the shales. For the resemblance of the Silurian shales, and especially of some soft nearly black bands, to Coal-measures is so striking, that in the absence of such fossil evidence the difficulty of separating them would have been greatly increased. Not only are the Silurian shales entirely uncleaved, and, except in the immediate neighbourhood of the intrusive igneous rocks, very little altered, but their dip agrees very closely both in amount and direction with that of the Coal-measures, especially in the southern part of the district. The clue once provided, however, it became easy to see (1) that the conformability of the shales with the Coal-measures is apparent only, there being in reality such evidences of discordance as might be expected between rocks so very different in age; (2) that the Coal-measures are based by an impersistent bed of sandstone containing pebbles of quartzite and of the local rocks, bearing evidence (as in South Staffordshire) of having been deposited in the hollows of a floor of gently inclined Silurian strata; while (3) it became clear that the intrusive igneous rocks are entirely of pre-Carboniferous age, and do not affect the Coal-measures in any way whatever.

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[1] On the Diorites of the Warwickshire Coal-field, Quart. Journ. Geol. Soc. vol. xxxv. p. 637, 1879.

[2] On the Discovery of Cambrian Rocks in the Neighbourhood of Birmingham, Geol. Mag. New Series, Dec. II. Vol. IX. p. 563, 1882 (reprinted from the Proc. Birmingham Phil. Soc. vol. iii. p. 234). See also Geol. Mag. New Series, Dec. III. Vol. III. p. 319, 1886.

The total thickness of the Coal-measures, as now shown, amounts to between 600 and 700 feet, in place of about 3000, as previously.

It will be convenient in describing these rocks to take them in order of age, beginning with the southern end of the range of each formation.

The Caldecote Series.

The oldest rocks are found near Caldecote, rising from beneath the quartzite on the north-east side of the range of low hills, which this rock forms between Nuneaton and Hartshill. They are referred to by Professor Lapworth as the Caldecote Volcanic Series, and consist, as he pointed out to me, of a finely-laminated rock, probably a tuff, with intrusions of diabase and quartz-porphyry.[1] There are very few exposures of these beds. About a quarter of a mile east of Caldecote Windmill, there is an abandoned quarry known as the 'Blue Hole,' from which paving cubes were formerly obtained. The rock in request was the diabase, but the workings on the north side intersected quartz-porphyry, which had been intruded into, and contained fragments of, a highly altered fine-grained ash. The diabase with a sharply-defined line of separation is found in the side of the quarry above the quartz-porphyry. Its intrusion is considered by Professor Lapworth to have taken place subsequently to that of the quartz-porphyry.[2] The tuff has been found again by Professor Lapworth in the entrance to an old tunnel 100 yards west of Caldecote Hill, where the presumed bedding-planes have a dip 25° to 30° in the same direction as the quartzite, that is, about south-west. The further extension of these beds is inferred from the occurrence of fragments in the soil, and from the position of the overlying conglomerate, which will now be described.

The Hartshill Quartzite.

The Hartshill quartzite extends from the Midland Station at Nuneaton to half a mile north of Hartshill, with a steady dip to the south-west of from 25° to 45°. The whole series can be seen in the series of immense quarries in which it is worked for road-metal. The base of the quartzite is a coarse stratified conglomerate or breccia, containing fragments of the underlying Caldecote series, some of the fragments ranging up to the size of half a brick, as was pointed out to me by Prof. Lapworth. The base is seen in the cutting by which Boon's Quarry is entered, about one-third of a mile south-east of Caldecote Windmill. The quartzite becomes coarse in grain towards the base and passes into a grit made up of small rounded grains of

[1] These rocks were referred to by Sir Andrew Ramsay in his evidence given before the Coal Commissioners as being of doubtful origin (Report of Coal Commission, vol. ii. p. 470). Eventually from the limited nature of the exposures, and the small advance that petrography had made at the time of the publication of the map, they were included in the index with the intrusive diorites under the general name of greenstone.

[2] Geol. Mag. for 1886, p. 320.

quartz and other rocks. This grit rests on the greenish and purplish coarse conglomerate or breccia mentioned above. A better exposure of the lower beds is found in the entrance to a quarry half a mile south-east of Hartshill. There there occur in the quartzite thin bands of intrusive igneous rocks much decomposed. The lower beds of the quartzite consist of bands of conglomeratic grit, well bedded and split up with shaly partings, and strongly impregnated with manganese. The conglomerate is seen for a thickness of more than eight feet, but the actual base is not exposed. There are also a few conglomeratic bands higher up in the quartzite, with pebbles ranging up to half an inch in diameter.

I may remark here that the Blue Hole and both the sections in which the basement conglomerate is exposed have been opened since the original survey of this district was made, and that it was therefore almost impossible at that time to determine the nature of the rock beneath the quartzite, and its relation to this formation. The true nature of the Caldecote Series and of the basement conglomerate of the quartzite was first detected by Prof. Lapworth.

The great mass of quartzite overlying this basement conglomerate is an intensely hard fine-grained siliceous rock, in which the original sand-grains are so closely cemented together by silica as to have almost lost individuality. The rock, however, is well bedded, and contains thin bands of green or purplish shales. It is used most extensively for road-metal, and nearly the whole series of beds is exposed in one or other of the great quarries. The quartzite is also traversed by sheets of intrusive igneous rocks, ranging from 3 to over 100 feet in thickness, and following the bedding with remarkable regularity. The igneous rocks are usually quite decomposed to a depth of from 30 to 40 feet from the surface, especially when in thin beds. They are locally known among the quarrymen as "Dun Dick," and when sufficiently fresh are "cut" (broken to size) into paving cubes. The price of the quartzite road-metal is 3*s*. a ton when broken to size. I was informed that a prepared cubic inch of quartzite crushed at a pressure of 24,000 lbs. to the square inch, the igneous rocks yielding at between 11,000 and 12,000 lbs. to the square inch.

A good exposure of one of these intrusive sheets is found in the Midland Company's Quarry at Nuneaton Midland Station. The quarry is principally in this thick sheet, the eastern part only being in quartzite. The jointing of the igneous rock, which at a distance resembles bedding, is nearly at right angles to the bedding of the quartzite, that is, perpendicular to the plane along which the melted rock has been injected. In this quarry the basement-bed of the New Red Sandstone may be seen lying across the edges of the quartzite and igneous rock, as will be described subsequently. Another great sheet is seen in the cutting by which a quarry on the east side of the high road, one-third of a mile south of Caldecote Windmill, is entered, and again close to the windmill. This sheet forms the boundary up to which the old quarries along the road were worked. Most of the quarries now worked are in beds below this sheet.

The Stockingford Shales.

The shales which overlie the quartzite occupy a considerably larger area. They extend from a little south of Bedworth to Waste Hill, one mile and a half north-west of Atherstone, a total distance of nine miles and a half. They are divisible into two perfectly conformable subdivisions, the lower, which rests quite conformably on the quartzite, being distinguished by a bright red tinge and by the presence of minute Brachiopods of the genera *Lingulella* and *Obolella*, the upper consisting of olive-coloured, grey, and thin black shales, with *Agnostus* and *Olenus*.[1] The shales are fine-grained and laminated and contain only a few harder and more sandy micaceous bands. They are altogether uncleaved, and present so close a resemblance to Coal-measures, as to have led (in the absence of fossil evidence and in view of their apparent conformity with the productive measures) to their having been originally classed as Lower Coal-measures.

They are traversed by very numerous sheets of intrusive diorite, etc. These igneous rocks are frequently found to follow a bedding-plane for many yards, and on a general view indicate the strike of the shale very accurately. On a close examination it becomes evident that the shale overlying each sheet of igneous rock is as highly altered as that below, and that frequently the igneous rocks break obliquely across the beds, or even swell out into bosses, forcibly contorting and thrusting aside the surrounding shales. These facts, indicating the intrusive character of the rock, were clearly recognized by the Rev. J. Yates in the year 1824.

The southern termination of this range of Lower Silurian shales is concealed by Drift. But the beds seem to have been found in a colliery shaft at Hawkesbury Basin, one mile south of Bedworth, where the following section was proved:[2]—

		ft.	in.
Coal-measures.	Bind, rock, and fire-clay with coal and ironstone	182	11
	Black shale-rock		6
	White rock-binds	1	6
	Alternations of hard black bat and granite-like rock in boulders	172	9
		357	8

Mr. Howell remarks that the "granite-like rock" was not a granite, but that, not having seen it *in situ*, he is unable to say whether it is trap or an altered sedimentary rock. It seems extremely probable, however, that the rock described as hard black bat was the altered Lower Silurian shale, and the granite-like rock some of the dioritic intrusions which are so numerous in this part of the shale, as seen at Chilvers Coton.

The most southerly exposure is at Marston Jabet in the old quarry in diorite figured in the Memoir on p. 39, but the first surface evidence we get of the boundary between the Coal-measures and the Silurian shales occurs in the railway south-west of Griff Hollow. The bottom of the railway cutting is in white fireclay with nodules of clay-ironstone, while the wood on the east side is planted over old excavations in flaggy Silurian shales, lying on the top of the thick mass of diorite which is seen at the point where the road crosses the Griff Canal. The boundary of the Coal-measures is marked by a shallow "strike-valley," due to the comparative softness of the beds.

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[1] This subdivision consists of two zones according to Prof. Lapworth, an upper zone characterized by *Sphærophthalmus alatus*, Beck., and a lower zone with *Agnostus sociale*, Tullberg, Geol. Mag. for 1886, p. 321.

[2] The Geology of the Warwickshire Coal-field (Geol. Survey Memoir), p. 20.

In the Chilvers Coton Railway-cutting we get a clear view of the Silurian shales, several intrusions of diorite, etc., and of the base of the Coal-measures. In walking from the station southwards we find first grey shales with a thin bed of diorite near the bridge. A few yards south of the bridge these shales pass under a thick mass of diorite, which extends to a distance of 150 yards south of the bridge; there its base is fully exposed. It rests upon shale dipping normally about west-south-west, but thrown into contortions immediately under the diorite. The base of the diorite is very straight and forms an angle of 25° with the horizontal. At first sight it resembles a fault of very low hade, but it seems on the whole more probable that its appearance is due to the diorite having broken through and across the shales at the time of its intrusion. Faults are rare in this neighbourhood, but evidences of the intrusive character of the diorite are abundant. The contortions of the shale moreover do not point to motion in any definite direction along the line of junction, but rather resemble the foldings produced in the leaves of a book by pressure straight upon their edges.

The shales which lie on the south side of this diorite have a steady dip to W. 10° S. of about 20°—30°. At 90 yards distance from their junction with the diorite just described, they are found to be split up by numerous strings and sheets of diorite and andesite, ranging from three inches to as many yards in thickness. These intrusive rocks, as is often the case, follow the bedding-planes very closely, so as to imitate contemporaneous lava-flows. But the alteration of the shale above, as well as below, the igneous rock is sufficiently marked to have determined the intrusive character of the diorite, without the conclusive evidence obtainable in other sections. The same shales occupy the cutting for a few yards further, until we are suddenly made aware of the fact that we have passed the boundary of the Coal-measures by the exposure of a seam of coal on the west side of the railway, as subsequently described.

The Coal-measures occupy the cutting to a distance of 130 yards south of the Accommodation Bridge, where the Silurian shales are brought to the surface again by a small fault. These shales dip to the north-east, and are highly altered by the influence of a sheet of diorite, which is seen in the cutting to rise from beneath them at 45 yards distance from the fault. The same sheet is well seen in a quarry behind Griff Hollow Farm, and in the high road close by. The diorites in this neighbourhood are much decomposed, and show spheroidal weathering even in the thinnest bands.

Another very admirable section has been opened in these rocks, in the Midland Railway between Nuneaton and Stockingford. The eastern end of the cutting is in red and grey or green shales, the red tinge being, as before mentioned, the predominating colour in the lower part of the Lower Silurian shales. The first sheet of diorite is met with a few yards east of the Accommodation Bridge. It is about 50 feet thick and contains a band of shale, 6 inches thick, about 3 feet from the top. This shale is of course highly altered, but the shale above and below the diorite has also been baked hard for a distance of about 6 or 8 feet. The top of the diorite is seen on the south side of the cutting and to the east of the bridge. On the west side of the bridge the overlying beds are seen to be pale grey shales with bands of black shale, the whole presenting an appearance very like that of Coal-measures. Further to the west the shales are seen to be traversed by numerous bands of diorite, etc., ranging from 1 to 8 feet in thickness, and in most cases following the bedding; but it may be noticed that some of the thicker beds thin out and reappear very suddenly, while on the south side of the cutting near the bridge, a sheet of diorite cuts across the beds of shale at an oblique angle. The western end of the cutting runs through pale fine shales with an occasional black band, or more sandy micaceous rocky bed. The dip increases westwards till the beds become nearly vertical.

The outcrop of the Lower Silurian shales throughout the northern part of the district ranges from one-half to one mile in width, and from the abundance of intrusive sheets and masses of diorite and other rocks, forms a prettily undulating country. The red beds which lie next above the quartzite can be well seen in Atherstone Outwoods; in a lane forming the south-east side of Purley Park; on the north side of Hartshill Heys; and near Hartshill. They are interstratified with pale grey or olive shales. The upper part of the shales are grey and contain dark, almost black, bands, and are well exposed at Oldbury Reservoir, in Monks Park, and in the Atherstone and Birmingham high road. The best section of the diorite is afforded by the great quarry at Oldbury Reservoir, where the whole thickness of a great sheet, with its junction with the shales above and below, is clearly seen. The description of this and of the other igneous rocks that have been referred to has been written by Mr. Rutley, and will be found at the end of this paper.

The following is a list of the fossils which were collected by Mr. Rhodes, fossil collector to the Survey, during the examination of this tract. Many of the best localities were pointed out to me by Professor Lapworth. The specimens have been identified by my colleague, Mr. G. Sharman.

Sponge spicules, *Protospongia fenestrata* ?, Salt.	Lane on S. side of Purley Park, 30 yards down. Grey shale. 1 specimen.
Pyritonema.	Lane on S. side of Purley Park, near top. Grey shale. 2 specimens.
Rod-like bodies, Annelids or Plants ?	Lane on S. side of Purley Park, near top. Grey shale. 1 specimen.

Rod-like bodies, Annelids or Plants?	Half a mile N.W. of Hartshill Castle. Red shale. 2 specimens.
,, ,, ,,	Atherstone Outwoods, 250 yards W.N.W. of Rawn Hill. Red shale. 15 specimens.
Annelid markings.	Griff Hollow Farm House. Grey shale. 1 specimen.
,, ,,	200 yards S.W. of Merevale Church. Grey shale. 3 specimens.
,, burrows and castings.	200 yards S.W. of Merevale Church. Grey shale. 11 specimens.
Dictyonema sociale, Salt.	200 yards S.W. of Merevale Church. Grey shale. 38 specimens.
Trilobites, fragments of.	200 yards W. of The Mawbournes. Grey shale. 3 specimens.
Agnostus, sp.	Road-cutting, ¼ mile S. of Chilvers Coton. Grey shale. 3 specimens.
,, *cyclopyge* ?, Tullberg.	Junction of Griff and Coventry Canals. Grey shale. 2 specimens.
Olenus Nuneatonensis, Shar.	W. end of Midland Railway cutting. Grey shale. 32 specimens.
,, sp.	W. side of Railway cutting, 300 yards S. of Chilvers Coton Station. Grey shale. 1 sp.
,, *Salteri* ?, Call.	W. end of Midland Railway cutting. Grey shale. 2 specimens.
Lingula lepis ?, Salt.	Marston Jabet. Red shale. 7 specimens.
Lingulella Nicholsoni, Call.	200 yards W. of The Mawbournes. Grey shale. 2 specimens.
,, ,,	Lane on S. side of Purley Park, 30 yards down. Black shale. 47 specimens.
,, ,,	Lane on S. side of Purley Park, 50 yards down. Red shale. 1 specimen.
,, ,,	Atherstone Outwoods, ¼ mile S.W. of Rawn Hill. Red shale. 8 specimens.
Obolella granulata, Shar.	Lane on S. side of Purley Park, near foot of hill. Red shale. 2 specimens.
,, *Sabrinæ* ?	Lane on S. side of Purley Park, near top. Grey shale. 3 specimens.
Theca, sp.	200 yards S.W. of Merevale Church. Grey shale. 2 specimens.

This list may be supplemented from the following specimens which have been collected from the Stockingford Shales by Professor Lapworth, and identified by himself.[1]

1. PURPLE AND GREEN SHALES.

Obolella sagittalis, Salt.
,, *Salteri*, Holl.
Orthis lenticularis, Wahl.
? *Lingulella pygmea*, Salt.
Protospongia fenestrata, Hicks.
Serpulites fistula, Holl.

2. BLACK AND GREY SHALES.

(*a*) Lower zones.

Agnostus pisiformis (*princeps*, Salt.).
Agnostus pisiformis, var. *sociale*, Tullberg.
Beyrichia Angelini, Barr.
Leperditia sociale, Brögger.
Lingulella Nicholsoni, Call.

(*b*) Upper zones.

Sphærophthalmus alatus, Bœck (*S. humilis*, Phill.).
,, ? *flagellifer*, Angelin.
Agnostus cyclopyge ?, Tullberg.
? *Dictyonema*.
? *Hymenocaris*.

Nearly all these fossils occur in some part or other of the Lingula Flags. *Protospongia fenestrata*, Salt., occurs in the Harlech Beds, and in the Menevian of South Wales (Mem. Geol. Surv. vol. iii. p. 472). *Dictyonema sociale*, Salt., is found in the uppermost Lingula Flags in North Wales (*ib.* p. 536), in the Shineton Shales (Tremadoc) in Shropshire, and at Malvern (Quart. Journ. Geol. Soc. vol. xxxiii.). *Agnostus princeps*, Salt., occurs in the Upper Lingula Flags, and Tremadoc Slate of North Wales, and in the Lingula Flags of South Wales (Mem. Geol. Surv. vol. iii. p. 489), and *Olenus Salteri*, Call., is common in the Shineton Shales of South Shropshire (Quart. Journ. Geol. Soc. vol. xxxiii. p. 666). *Lingula lepis*, Salt., ranges from the Lower Lingula Flags to the Arenig (Mem. Geol. Surv. vol. iii. p. 538), but is commonest in the Tremadoc. *Lingulella Nicholsoni*, Call., and *Obollela Sabrinæ*, Call., are common in the Shineton Shales (Quart. Journ. Geol. Soc. vol. xxxiii.).

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[1] This list was furnished to me in MS. by the kindness of Prof. Lapworth. He remarks that *Obolella sagittalis*, *Lingulella pygmea*, and *L. Nicholsoni*, may be all of them varieties of *L. lepis*.

In Professor Lapworth's list we find the following additional forms: *Obolella sagittalis*, Salt., which occurs in the Menevian of North and South Wales; *O. Salteri*, Holl, known in the Upper Lingula Beds of Malvern; *Orthis lenticularis*, Wahl., which occurs in the Upper Lingula Flags (Dolgelly group of Belt); *Lingulella pygmea*, Salt., of the Upper Lingula Flags; *Serpulites fistula*, Holl, from the same beds near Malvern; *Sphærophthalmus* (*Olenus*) *alatus*, Bœck, of the Upper Lingula Flags, and the black shales of Malvern; *S. flagellifer*, Angelin, which occurs in the Lingula Flags, and is believed to range up into the Tremadoc.

It may be concluded that the Stockingford Shales belong to a late Lingula Flag age, including possibly a portion of the Lower Tremadoc series.

The base of the Coal-measures.

The most southerly point at which the position of the base of the Coal-measures has been definitely fixed is the colliery at Hawkesbury Basin, previously alluded to. There the Silurian rocks (presumably) were entered at a depth of 115 feet 5 inches below the Bench Coal, the lowest seam worked in this coal-field. We next find evidence of its position in the railway-cutting near Griff Hollow, as has been described. But in the cutting at Chilvers Coton the junction is fully exposed to view. A coal-seam is seen on the west side of the cutting 116 yards north of the Accommodation Bridge (the second bridge south of Chilvers Coton). This seam is underlain by three feet of white fireclay, which rests upon about eight inches of sandstone. On clearing the soil from the base of this sandstone, it may be seen that it rests upon soft blue laminated shale, weathering yellow, and obviously forming part of the same set of shales in which the intruded diorites described above occur. The dip of the Coal-measures is nearly in the same direction as that of the shales, but is less rapid, so that by clearing a sufficient length of junction it may be seen that there is an actual unconformity. The Coal-measures occupy the cutting to a distance of 130 yards south of the Accommodation Bridge, where the Lower Silurian shales are brought up again by a small fault running about S. 35° E., the evidence for the fault being the fact that the dip of the Coal-measures continues to be southerly, that is, towards the Silurian shales, close up to the point where these shales reappear. This point is marked by slips in both sides of the cutting, necessitating the covering up of the side-drains.

From Chilvers Coton northwards there is no section showing the base of the Coal-measures for nearly four miles, but its position is indicated by the rise of the ground, where the harder Silurian shales with the intruded diorites rise to the surface. There can be little doubt that the Coal-measures rest almost directly upon the highest beds seen in the Midland Railway cutting near Stockingford, for it is known that the workable coal-seams crop out in the depression which lies at the west end of the cutting. They are not exposed, but two or three hundred yards south of the Accommodation Bridge there is an old pit, now ploughed over, in which fragments of soft Carboniferous sandstone occur, and which probably marks the position of the boundary of these beds. On following the boundary northwards, we find it marked by the outcrop of a seam of coal in the bed of the stream west of Camp Hill, the hill itself consisting of the shale with diorites, etc., seen in the western part of the railway cutting. The coal-seams, which have been for the last two miles resting close upon the Silurian shales, now begin to be separated from them by beds which thicken steadily northwards. The nature of these beds is first seen near Oldbury Hall. A pebbly sandstone dipping gently to the west, and resting with a marked unconformity on the Silurian shales, may be traced continuously from here to the Atherstone and Birmingham high road. The rock is seen in the sides of a pond at Oldbury (Farm); in the foundations of the farm west of Hopwood Coal Wood; in a sandpit near The Mawbournes; and in some old quarries 200 or 300 yards further west in the edge of the wood. The rock is buff-coloured or white, and so soft as to be readily broken down into sand by the use of a pick. It is associated with some mottled red and white clays, which are exposed in the brook near the south-west corner of Hopwood Coal Wood, and were found in laying the pipes of the Atherstone Waterworks along the lane which passes the sand-pit. The red tinge, however, is not confined to the lowest beds of the Coal-measures, but may be seen in many of the fireclays associated with the workable coal-seams. The sandstone is seen again in the north part of Monks Wood in an old pit close to a small quarry in diorite and Silurian shale, and again in the side of the bridle-path leading into the high road, but from this point northwards the beds which underlie the coal-seams rapidly disappear, until the seams come down, as at Stockingford, close on top of the Silurian shales.

The unconformity between the Coal-measures and the Lower Silurian shales, which is generally masked on this side of the Coal-field from the accidental parallelism between the bedding of the two formations, is here very marked. The dip of the Coal-measures is slight, ranging from 6° to 8°, while that of the Silurian shales ranges from 20° to 40°. As a consequence of this the Coal-measures, where they extend eastwards, at Mawbournes, overlap a great thickness of the shales, including two sheets of igneous rock. The Pre-Carboniferous age of the igneous intrusions, which might have been inferred from their absence in the Carboniferous rocks and abundance in the Lower Silurian shales, is thus placed beyond doubt.

On passing Merevale the lower beds of the Coal-measures again thicken out rapidly, with the development of a pebbly sandstone at the base as before. The best section of this basement bed is found in the Baddesley Mineral Railway, but it may be traced from Merevale Brook to a little north of Waste Hill.

Dosthill.

While Professor Lapworth was investigating the neighbourhood of Nuneaton and Atherstone, the igneous rocks of Dosthill, on the opposite side of the Coal-field, were visited by Mr. W. J. Harrison, F.G.S., with the result of finding that shales similar to those of Atherstone occurred here also.[1] The shales are first seen where the footpath to Dosthill intersects the road to the Ford. They are immediately overlain by a pebbly sandstone which forms the base of the Coal-measures, and which may be traced southwards along the west side of the lane, through the churchyard and neighbouring farm-buildings. Immediately to the south of the village this sandstone thins rapidly out, and the coal-seams come nearly, if not quite, into contact with the diorite. But after passing the most southerly of the igneous rocks, this sandstone reappears. There is no good section in it, but its course can be followed without difficulty across the ploughed land.

The shales are seen in the side of the high road a quarter of a mile south of Dosthill; in a small pit near Stockall Barn; in the side of the high road again near the word 'mill'; and lastly in the brook which comes down from the Brick Works.[2] The dip is in all cases towards the south-west, at angles varying from 20° to 40°, and therefore in nearly the same direction as on the east side of the Coal-field. The dip of the Coal-measures, on the other hand, is towards the east, and generally at a high angle (from 50° to 80°), so that the unconformity is most conspicuous. The shales are highly altered grey and olive-coloured sandstones. No red beds are seen, and at present no fossils except worm-tracks[3] have been found. There is a strong resemblance, however, in these shales to the Nuneaton and Atherstone beds, and there can be little doubt that they also are of Lower Silurian age.

The Base of the Coal-measures continued.

The nature of the evidence, on which the base of the Coal-measures has been drawn upon the map (now for the first time), has been given above. It has been shown that the actual base is formed in some cases of a conglomeratic sandstone, with a considerable thickness of strata intervening between the coal-seams and the Silurian platform, while in others the coal-seams appear to rest almost directly upon this platform. The impersistency of these lower beds led Professor Lapworth to conclude that the Stockingford shales were brought "in a long-curved strike fault against the Coal-bearing beds of the Upper Carboniferous."[1] The same view was taken by Mr. Harrison also, who writes that the line of fault between the Coal-measures and the Stockingford Shales is "marked by a line of brick-pits in which the rubbed-up material or 'fault-stuff' is worked," and again, in reference to Dosthill, that "on the west of the hill . . . . a line of fault runs, by which the Triassic strata are placed on a level with the Cambrian shales, while on the eastern side a parallel fault of less 'throw' places the Coal-measures in a similar position."[2]

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[1] Geol. Mag. 1882, New Series, Dec. II. Vol. IX. p. 565.

[2] The position of the boundary fault of the New Red Marl is marked in this brook by a rubble of diorite resting against red and white clay. Lumps of a white siliceous vein-stuff containing specks of galena may be picked out of the white clay.

[3] Harrison, Midland Naturalist, vol. viii. 1885.

The mapping of the boundary, however, about Oldbury, placed it beyond doubt that in this neighbourhood it was not a fault, but an unconformable superposition of the one series upon the other, while the section at Chilvers Coton proves that the absence of the conglomeratic sandstone is due to attenuation and does not imply a fault. Nor in the intermediate ground is there any reason to attribute the varying distance of the seams from the top of the Silurian rocks to a fault rather than to the known variability of the lower beds of the Coal-measures, the material referred to by Mr. Harrison as 'fault-stuff' being merely such fireclays and shales as are commonly found in connection with seams of coal in the Coal-measures. The relations of the Coal-measures to the Silurian platform appear to be exactly paralleled by those of the Coal-measures of South Staffordshire to the platform of the Upper Silurian rocks, on which they rest in that county. Professor Jukes writes[3] that "the Silurian rocks were greatly denuded and worn away, and cliffs and hollows formed in them, on, against, and over which the Coal-measures were deposited, both lying in a nearly horizontal position" (p. 81); and again, "We have already, in examining the base of the Coal-measures, seen the way in which at particular spots the lower beds of that formation filled up hollows in the Silurian rocks and obliterated their little pre-existing cliffs, and thus formed a smooth floor for the deposition of the chief mass of the Coal-measure beds" (p. 135).

These words describe exactly the manner in which the earlier beds of the Coal-measures appear to have been laid down in Warwickshire. We have here a platform of rocks varying in hardness, and forming in consequence such peculiarly undulating ground as is found near Merevale. At the commencement of the Carboniferous period they must have presented just such a surface for the reception of the first deposited sediments, the igneous rocks standing up, as now, in small hills above the general level of the shales, and it seems to have resulted from this that a thick mass of sandstones and clays was deposited at Oldbury and Waste Hill, while the bosses of diorite, etc., about Merevale remained still uncovered. Similarly, at Dosthill the diorite seems to have formed a small elevated area, bare of sediment, while conglomeratic sandstone was being deposited on its flanks.

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[1] Geol. Mag. Dec. II. Vol. IX. p. 565.

[2] Midland Naturalist, vol. viii. p. 72, 1885.

[3] The South Staffordshire Coal-field (Memoirs of the Geological Survey), second edition, 1859.

The Base of the New Red Sandstone.

From the south end of the Warwickshire Coal-field northwards to Nuneaton, the New Red Sandstone (Waterstones) rests unconformably, first on Coal-measures, then on the Silurian shales and diorites, the junction being exposed in an old quarry at Marston Jabet,[1] and in Wash Lane, Nuneaton. In both cases soft red and white sandstone, based by an inch or two of breccia, is seen resting on diorite and shale. The same boundary-line is seen again in the Midland Co.'s Quarry near Nuneaton Station (Midland Railway). The beds, which are flaggy and resemble parts of the New Red Marl (into which the Waterstones shade insensibly), are seen resting on a very uneven floor composed in part of a sheet of igneous rock, and in part of quartzite. The hollows in this floor are filled with a breccia of large fragments of quartzite, sometimes a foot across, while three or four feet from the bottom of the red beds there is seen a conglomeratic band containing well-rounded pebbles of quartzite, from ½ to 1 inch in diameter.

From this point northwards, however, the boundary of the Trias is shown as a fault. The evidence of this is given by Mr. Howell as follows.[2] The coals were wrought in the old workings near Polesworth Station up to a "Red Rock Fault" and there entirely cut off. Near Dordon the coals were found to be so much faulted that the workings were not proceeded with. Lastly, a fault falling into the same line is seen in a quarry in Merevale Park (p. 50). The absence of the Lower Keuper Sandstone (Waterstones) between Atherstone and Nuneaton is also taken as evidence of a fault, and it may be added that the nearly straight course taken by the boundary is in a general way suggestive of a fault rather than of a natural superposition. The existence of such a fault, however, has been questioned by Mr. W. Andrews,[3] and borings made since the date of the original survey of the ground have proved that the fault, if it exists, has not the importance which might have been attributed to it. For it might have been supposed that the Coal-measures would occur beneath the Red Marl on the east side of the fault, having been thrown down with this rock against the older Palæozoic strata. The absence of Waterstones, moreover, does not necessarily imply the presence of a fault, for these beds constitute merely the earlier and more sandy sediments of the New Red Marl, and are known to be quite unrepresented in some other localities where the Red Marl mantles round bosses of old rock, as at Croft, Sapcote, etc.

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[1] Geology of the Warwickshire Coal-field (Memoirs of the Geological Survey), p. 39, fig. 4.

[2] Geology of the Warwickshire Coal-field.

[3] In a paper read at the Annual Meeting of the Warwickshire Naturalists' and Archæologists' Field Club, 1884. A different view was taken by Prof. J. Phillips, who refers to the "curious circumstance, that the Nuneaton coal-field terminates on the north-eastern [side] by a magnificent line of fault. It is one of the grandest lines of fault which can be seen anywhere, and along that line of fault there are the effects of metamorphosis; there are considerable bursts of trap-rock" (Coal Commission Report, 1871, vol. ii. p. 494). The trap-rock referred to appears to be the Caldecote Volcanic Series, which is of course of vastly greater antiquity than the fault.

That there is a fault, however, along the northern part of the coal-field appears to have been proved, and that it extends southwards as far as shown, though perhaps with no great throw, seems probable. Near Hartshill Wharf is a quarry in quartzite in which the base of the Trias is seen, the lower beds consisting of about three feet of sandstone, overlain by about three feet of marl, and lying upon the quartzite. The beds undulate and when last seen are dipping steeply, as though near a fault. If there is a fault here, the Triassic beds seen must be on the west or upthrow side. The section proves therefore that the Trias rests upon the quartzite here, without any of the Coal-measures intervening.

At the brick-pit near the canal by Nuneaton Midland Station, the Red Marls are seen with a dip ranging up to 35°. The quartzite rises to the surface close by, but the junction is not exposed. The steepness of the dip of the Marl, however, points to the boundary being probably a fault.

We have, then, four instances in which the Trias is seen resting directly upon the Silurian rocks, namely, Marston Jabet, Wash Lane, the Midland Co.'s quarry, and Hartshill Wharf. This evidence alone would have been sufficient to indicate that the Trias of the great plain on the north-east of the Warwickshire Coal-field would probably be found to rest in great part on the older Palæozoic rocks, and not on Coal-measures, especially when it is remembered that the nearest exposure of Palæozoic rock to the east (namely, at Sapcote) shows syenite rising through the Marl. But this conclusion has been placed beyond doubt by the results of borings, some of which have reached the base of the Triassic rocks, and proved the depth to the Palæozoic floor. The following is a list of those which bear upon the district under consideration.

HAWKESBURY PUMPING STATION; about five miles south of Nuneaton. 252 feet above Ordnance Datum.[1]

Drift	30 feet.
Lower Keuper Sandstone [Waterstones]	90 ,, [1]
	120 ,,

THE WHITE STONE, about 2½ miles south-east of Nuneaton. A well to a depth of 80 feet, a borehole to a further depth of 50 feet. Height above Ordnance Datum about 250 feet.[2]

White sandstone and red shale [Waterstones]	60 feet.
Hard mottled blue and purple shales	70 ,, [1]
	130 ,,

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[1] Report of the British Association for 1875 (Report of the Committee on the Circulation of Underground Waters), pp. 135, 136. For the Nuneaton boring see also Report for 1878, Report on the Circulation of Underground Waters, p. 7.

[2] The details of this section were given me by Mr. W. Andrews. The Waterstones are well exposed in a quarry by the side of the L. and N. W. Railway, near Attleborough.

At the time of my visit, April, 1886, the débris from the pit was in a fresh condition. The character of the shales left no doubt that they were of Silurian age, and probably of the same age as those that crop out at Marston Jabet. Some of the fragments were intersected by veins of gypsum, doubtless derived by infiltration from the Trias above. No fossils have been found.

Nuneaton: centre of the town. 210 feet above Ordnance Datum.[1]

Drift (sand, gravel, and clay)	18 feet.
Red Marl	12 ,,
Lower Keuper Sandstone [Waterstones]	80 ,,
Hard slaty white rock [probably Hartshill Quartzite]	2 ,,
	112 ,,

Lindley Hall Estate; boring near the Fenn Lanes. About three miles north of Nuneaton.

Soil, red clay, etc., (Drift)	6 feet.
Red marl with red and blue rock and gypsum	456 ,,
Blue, red, and brown rock with marl, probably Waterstones	181 ,,[1]
	643 ,,

Hinckley Wharf, about three miles east-north-east of Nuneaton, 313 feet above Ordnance Datum.[1]

Glacial Drift	Sands and Boulder-clay	88 feet.
Red Marls	Red gypseous marls with bands of grey sandstone	408 ,,
Waterstones	Red, grey, and brown sandstones with bands of marl	209 ,,[1]
		705 ,,

This boring is nearly midway between the exposures of Palæozoic rocks at Nuneaton and Sapcote, and is probably near the deepest part of the trough of Triassic rocks separating these localities. It shows that the lower sandy beds of the Red Marls, which are distinguished by the name of the Waterstones, increase rapidly in thickness on receding from the old land-barriers or islands, formed by the harder parts of the Silurian and pre-Silurian series. In this they may be compared to the impersistent sandy and conglomeratic beds which form the base of the Coal-measures, as previously described.

Hinckley; at the Holy Well, 330 feet above Ordnance Datum [should be 421].[2]

Drift (pebbly clay, sand, and gravel)	150 feet.
Red marl	20 ,,
Lower Keuper Sandstone (viz. *thin* beds of clay and gypsum alternating with *thick* beds of red, grey, and white sandstone) [Waterstones]	370 ,,
	540 ,,

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[1] Report of the British Association for 1882. Report on the Circulation of Underground Waters, pp. 14, 15, where the section is given in full.

[2] Report of the British Association for 1875 (Report of the Committee on the Circulation of Underground Waters), pp. 136, 137. For a further account of the Hinckley Boring see Report for 1879, p. 160.

Elmesthorpe Boring, at Sapcote Freeholt, two miles east of Hinckley and two miles west of the syenite boss of Sapcote. 300 feet above Ordnance Datum.[1]

Drift	10	feet.
Red Marl	120	,,
Lower Keuper Sandstone [Waterstones]	330	,,
Slaty rocks with a dip of 70°, Lower Silurian?	980	,,
	1440	

This boring appears to have subsequently reached a depth of 1655 feet from the surface without meeting any change of ground.

Lindridge Colliery Company (Landridge ?), one mile north of Desford. 400 feet above Ordnance Datum.[2]

Drift	2	feet.
Upper Keuper Sandstone	20	,,
Red Marl (marl with thin bands of gypsum)	44	,,
Lower Keuper Sandstone. Waterstones	204	,,
	270	,,

Newton Unthank, near Desford Station. One mile and a quarter E.S.E. of the Lindridge section, 320 feet above Ordnance Datum.[3]

Drift	6	feet.
Upper Keuper Sandstone and Marls	56	,,
Red Marls with sandstone	80	,,
Waterstones	120	,,
Coal-measures [?]	353	,,
	615	,,

There have been also borings, of which details are not forthcoming, at the undermentioned localities:—

Near Kingshill Spinney, one mile and a half south-west of Market Bosworth, ending at a depth of about 672 feet, probably in Waterstones.

At Bosworth Wharf, one mile west of Market Bosworth.

At Cowpasture, three-quarters of a mile north-east of Market Bosworth, said to have entered Cambrian or Lower Silurian rocks at 400 feet.

Near Gabriel Pool, ¾ of a mile N.N.W. of Newbold Vernon, to a depth of 266 feet.

Newbold Heath, half a mile W.S.W. of the Landridge boring mentioned above, in which Coal-measures were said to have been proved at a depth of 400 feet.

There can be little doubt therefore that, as pointed out by Mr. Harrison,[4] the Trias rests directly upon rocks older than the Coal-measures over a large part of the area. Whether or no the Coal-measures were ever deposited continuously over the area remains an open question. It is certain that the Silurian rocks had suffered

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[1] The lower part of this subdivision was attributed to the Permian by Sir Andrew Ramsay, who gave the following details (Report of the Coal Commission, 1871, vol. ii. p. 134):—

Permian	Loose sandstone	64	feet.
	Hard sandstone	17	,,
	Light and dark sandstone	43	,,
	Pebbles, hard conglomerate	2	,,
	Pink and purple marls	15	,,
Coal-measures	[now known to be Silurian or of earlier age]		
		141	,,

[2] Report of the British Association for 1875 (Report of the Committee on the Circulation of Underground Waters), p. 137.

[3] Report of the British Association for 1878 (Report on the Circulation of Underground Waters), pp. 6, 7.

[4] Midland Naturalist, vol. viii. (1885).

enormous denudation in pre-Carboniferous times, so great indeed as to remove the whole of the series, consisting in the aggregate of several thousand feet of rock, from parts of Leicestershire. And it is probable that in the period of submergence that succeeded this continental epoch most of even the higher parts of the old land-surface in this neighbourhood were overspread by the latest Coal-measure sediments. But, however this may have been, the Carboniferous rocks were swept bodily off large areas in the Midland Counties in the long period of denudation which preceded the Trias. There are therefore two questions to be taken into consideration, in speculating on the possible presence of Coal-measures under the Trias at any point in the Midland Counties: firstly, whether the Coal-measures ever existed at that point; secondly, whether, having existed, they were subsequently removed by pre-Triassic denudation. It is scarcely possible to attach too much importance to the study of the great unconformity at the base of the Trias. In the present instance it seems certain, that though the Coal-measures may have been deposited in a continuous sheet between the Leicester and Warwick Coal-fields, they were certainly swept clean off, as far north as Market Bosworth and perhaps further, before the Waterstones and Marls were deposited.

Appendix I.

III.—The Igneous Rocks, etc., of the Neighbourhood of the Warwickshire Coal-field.

By Frank Rutley, F.G.S., etc.

THESE rocks may be classed into five or six more or less distinct groups.

i. Syenitic Rocks (Croft Series).
ii. Andesite and Andesitic Tuffs (Caldecote Series).
iii. Hartshill Quartzite with Breccia at its base.
iv. Diorites.
v. Andesites or Diorites containing Augite.
vi. Basalts or Diorites containing Olivine.

The three last groups appear to graduate into one another, and seem to correspond with similar rocks described by Mr. Allport.[1] Many of the specimens examined are in a more or less advanced stage of decomposition, calcite, serpentine, pyrites, etc., being very commonly present.

The best example of diorite in the series is that from the Oldbury Reservoir. These rocks are of special petrographical interest since so few diorites have been found in England. The mineral constitution of some of these rocks is such that they are also interesting from the transitional characters which they present between diorite, basalt and andesite or diabase. The pseudomorphs after olivine met with in the sections of rock here described might rather, as a rule, be called metasomata, since well-developed forms of the original crystals are often wanting, and it is seldom that any unaltered olivine is present. The replacing substance is frequently calcite. Accepting, therefore, the conclusions of Allport, who was fortunate in finding good crystals of unaltered olivine in some of the dioritic rocks of this district, and coupling them with such evidence of the former presence of this mineral as the sections, here described, afford, there seems little doubt that we have, in some cases, rocks which may often, with equal justice, be termed either olivine-bearing diorites or hornblendic basalts. On the other hand, the association of augite with hornblende in some of these rocks, also described by Allport, gives rise to a like ambiguity, since in these we may have either hornblendic diabases or andesites, or augitic diorites.

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[1] On the Diorites of the Warwickshire Coal-field, Q.J.G.S. vol. xxxv. p. 637.

The term augite-diorite has already been employed by Zirkel,[1] and its use advocated afresh by Grenville A. J. Cole.[2] The sanction of such a term, although its meaning is evident and not opposed to the observed mineral constitution of these rocks, may however, lead to some present confusion in petrological nomenclature, since the currently accepted definition of a diorite indicates that the constituent minerals are essentially triclinic felspar (labradorite or oligoclase) and hornblende. The important point in naming rocks of this mixed character is to indicate their relationship on either hand to sharply and of course arbitrarily defined rock types when their position is so evenly balanced between two types that the rock cannot be referred to the one type more than to the other, and, to indicate this, I would suggest that the names of the two nearest types should be combined, a preponderating affinity towards the one type or the other being denoted by underlining the name of the dominant type. Thus in the case of those olivine-bearing rocks which approximate on the one hand to diorites and on the other to basalt, we should have

Diorite. Diorite-Basalt. Diorite Basalt. Diorite-Basalt. Basalt.

A nomenclature based upon mineralogical terms only is never likely to be adopted, since it is far too cumbrous. Rock-names taken singly fail to indicate transitions in mineral constitution, while a mixture of mineralogical and petrological names at once impairs the needfully, but unnaturally sharp definition of a type. It therefore seems better to employ already well-known words and preserve, so far as possible, the landmarks of classification, than to destroy the meaning of a term by a mineralogical prefix or affix which in conveying a small truth may breed a great misconception. If, for instance, augite or olivine were assumed to be anything more than occasional and subordinate constituents of a diorite, the commonly accepted definition of that rock would become worthless, since the term diorite would then embrace a number of rocks of far greater importance and wider distribution, which have hitherto been distinguished by other names.

That a relationship exists between such rocks, and that they graduate one into another, is too well known to need any comment, but, to have classification, more or less clear definitions must be employed; without these the whole series of basalts, andesites and diorites may as well be called Greenstones.

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[1] "Lehrbuch der Petrographie," vol. ii. p. 7, Bonn, 1866.

[2] "The Igneous Rocks of Stanner," GEOL. MAG. Decade III. Vol. III. p. 225 (May, 1886).

I. Syenitic Rocks.

Croft.[1]

Pinkish-grey crystalline rock, resembling a fine-grained granite and apparently composed of pinkish or flesh-coloured felspar, a very little dark mica, quartz, and some dark specks of hornblende and magnetite. Under the microscope the rock is seen to have a holo-crystalline granitic structure, and to consist chiefly of orthoclase and triclinic felspars, quartz, hornblende and magnetite, with possibly a little magnesian mica. The amount of triclinic felspar present renders it necessary to distinguish this rock from an ordinary quartz-syenite. It is an orthoclase-plagioclase syenite, in other words it occupies a position between quartz-syenite and quartz-diorite.

Croft.

A pinkish-brown crystalline rock with numerous white, porphyritic crystals seldom over one-eighth of an inch in diameter, and small dark greenish-black and black specks. The specimen has a weathered appearance.

Under the microscope it is seen to consist of orthoclase, a triclinic felspar, which from some of the extinction angles seems to be albite, hornblende in small irregularly developed crystals which are sometimes represented by serpentinous pseudomorphs and crystals and irregular grains of magnetite. Quartz occurs plentifully. The rock is essentially a quartz-syenite. It is a more coarsely crystalline rock than the preceding.

Croft.

A purplish or reddish-grey, fine-grained crystalline rock, with dark brown spots ranging up to an eighth of an inch in diameter.

Under the microscope the chief constituents are seen to be felspars, all of which are greatly altered, so that their optical characters afford no clue to the species, quartz, serpentine, apparently pseudomorphous after hornblende, and ilmenite partly converted into leucoxene.

The rock seems to be a decomposed, fine-grained, quartz-syenite.

II. Andesite and Andesitic Tuffs, Caldecote Series.

Old tunnel, near Caldecote Hill.[2] Caldecote Series.

A finely-laminated greenish-brown rock, resembling a fine-grained sandy-mudstone or slate. The specimen is bounded by parallel joint-planes. Under the microscope, with a power of about 75 linear, a considerable proportion of the rock appears between crossed Nicols to consist of isotropic matter finely stippled with very minute doubly refracting granules and traversed by irregular wavy films of a serpentinous or sericitic substance, which commonly runs in sinuous streaks approximately parallel to the lamination of the rock. The entire section is profusely spotted with small crystals and fragments of crystals of felspar and augite, the latter mineral being usually represented by pseudomorphs of limonite. Some of the sections of augite crystals undergo maximum extinction at an angle of about 39° from the vertical axis, while other sections transverse to the vertical axis show approximately right angles formed by the adjacent faces of the oblique rhombic prism. The felspars are generally labradorite. Taking into consideration all the characters presented by this rock, it seems highly probable that it is an altered andesitic tuff.

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[1] See also "On the Pre-Carboniferous Rocks of Charnwood Forest," by the Rev. T. G. Bonney and Rev. E. Hill, Q.J.G.S. vol. xxxiv. pp. 119-239, 1878.

[2] See also T. H. Waller, Geol. Mag. 1886, p. 323.

"Blue Hole," east of Caldecote Windmill.[1] Caldecote Series. (The Quartz-Porphyry.)

Rock composed of pink and greyish-white crystals of triclinic felspar with grains of quartz, in a dark bluish- or brownish-grey matrix, the latter constituting the smaller proportion of the rock.

Under the microscope the general appearance is that of a tuff, composed of crystals or fragments of crystals of triclinic felspar and quartz more or less corroded, together with fragments of eruptive rock of an andesitic type, containing serpentinous pseudomorphs after pyroxene. The porphyritic felspar crystals, all of which have their angles rounded, are often corroded superficially and their angles of extinction indicate, as a rule, that they are labradorite. The quartz crystals are also rounded, and frequently show inlets of corrosion, which are much more strongly marked than in the felspars. The material in which these crystals and fragments are embedded is felsitic in character, and as it seems to be continuous with the felsitic matter which fills the corrosion-creeks in the quartz-crystals, it appears probable that it may be a product of devitrification, and that the rock is a tuff resulting from fragments taken up in a magma which, on solidification, assumed a vitreous condition. The general appearance of this rock under the microscope is rather like that of certain porphyritic pitchstones occurring in Saxony, except that in the latter the porphyritic crystals or fragments are usually less numerous and the ground-mass retains its glassy character. It seems probable that this rock from Caldecote is part of a lava-flow or dyke which has taken up fragments of other rocks in such quantity that it simulates an ordinary volcanic tuff.

"Blue Hole," east of Caldecote Windmill. Caldecote Series. (Junction of Quartz-Porphyry and Andesite).

Compact bluish-grey to brownish-grey rock with splintery fracture. The small specimen contains in one part greyish-white to pinkish-white specks of felspar, the largest being about $\frac{1}{16}$ inch in diameter. Minute grains of quartz are also visible with a lens.

Under the microscope, between crossed Nicols, the section seems to consist chiefly of a crypto-crystalline to micro-crystalline admixture of felspar and quartz, with some irregularly-shaped and usually rounded grains which, by ordinary transmitted light, appear of a brownish-green colour, and which are probably altered fragments of crystals of pyroxene or amphibole. A similar green or brownish-green substance (chlorite?), accompanied by minute specks of opaque-white matter (kaolin), constitutes irregular stringy markings and sinuous bands, which traverse the section, in some cases simulating fluxion structure, the material between such bands sometimes differing in texture from that on either side. This seems to be due to the presence of fragments of rock, whose margins are ill-defined, except through the contact of the chloritic films and strings. Small angular and rounded fragments of felspar crystals are plentifully distributed throughout the section, and here and there opaque grains of ilmenite, partly converted into leucoxene, are visible.

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[1] See also T. H. Waller, Geol. Mag. 1886, p. 323.

The porphyritic crystals and fragments of crystals of felspar mostly give extinction angles approximating to 40°, and may therefore be regarded as anorthite. In a few cases, however, labradorite occurs.

Judging from the section, it seems probable that this rock is a tuff composed of lapilli of some rocks allied to andesite or porphyrite in which the ground-mass was once vitreous or partly so.

"Blue Hole," east of Caldecote Windmill.[1] Caldecote Series. (Andesite.)

Compact purplish-grey rock, in which a few minute felspar crystals may be detected with a lens.

Under the microscope the section is seen to consist of crystals of triclinic felspars and magnetite in a felsitic or aphanitic ground-mass, in which numerous very minute crystals occur, which are apparently hornblende, since in some cases they give an extinction angle of 19°.

If these small crystals be hornblende, the rock is probably a hornblende andesite. It is somewhat decomposed, the specimen effervescing slightly when treated with acid. Isotropic matter seems to be present and it is quite possible that the rock may have originally possessed a more or less glassy ground-mass, some of the unaltered vitreous matter being apparently still present.

III. Hartshill Quartzite with Breccia at its base.

Base of Hartshill quartzite, half a mile S.E. of Hartshill.

A coarse breccia consisting of angular fragments embedded in a bluish-grey to purplish matrix. On a cut surface of the specimen some of the fragments are of a dark slate-colour or purple, while others are of a rather pale greenish-grey. The fragments do not seem to exceed half an inch in diameter, and most of them are of much smaller dimensions.

Under the microscope the fragments are seen to be of a mixed character. A few consist of eruptive rock, one or two showing distinct felspar crystals (labradorite), while one fragment contains small vesicles filled with a pale green substance (chlorite?). Quartz grains constitute a large proportion of the rock, and most of the other fragments and grains consist either of greatly decomposed felspar, converted into felsitic matter, or fragments of quartzite, and fragments of slate, together with grains of magnetite. The fragments of volcanic rock appear to be of an andesitic type. The slate fragments are the largest and the most numerous.

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[1] See also T. H. Waller, Geol. Mag. 1886, p. 324. The Dark Basic Rock.

Hartshill Quartzite.[1]

A very fine-grained pinkish-grey rock resembling quartzite.

Under the microscope the rock appears to consist chiefly of irregular crystalline grains of quartz containing numerous minute fluid lacunæ, with a few grains of felspar, which from the extinctions are seen in some cases to be microcline, in others anorthite. Grains of a clear, colourless, isotropic mineral are also present, which are probably garnet. Here and there but quite rarely a little microcrystalline siliceous matter may be seen lying in thin films or occupying small spaces between the quartz grains. The rock is essentially a quartzite.

IV., V. and VI. Diorites; Andesites, or Diorites containing Augite; Basalt, or Diorites containing Olivine.[2]

The specimens are taken in geographical order.

Marston Jabet. Intrusive in Lower Silurian Shales.

A rather coarsely crystalline greenish-grey rock, consisting of greyish crystals of felspar, a dark green mineral, calcite and specks of pyrites.

Under the microscope the section shows, triclinic felspar crystals (labradorite), serpentinous matter pseudomorphous after hornblende, the crystals being frequently about $\frac{1}{16}$ inch in diameter and giving in sections transverse to the vertical axis the usual prismatic angle for hornblende. These pseudomorphs are mostly flecked with an opaque yellowish-white substance probably leucoxene. Well-defined pseudomorphs of leucoxene after ilmenite are also present, the alteration being so complete that scarcely a trace of the original mineral remains. Spots of pyrites and large patches of calcite occur, and serpentine, frequently fibrous and in spherical groups of divergent fibres, often fills the spaces between the larger crystals. Apatite is also plentiful in well-formed crystals. The rock is a diorite, as pointed out by Mr. Allport in the paper already cited, where descriptions of the microscopic characters of this rock in its fresh condition and in various stages of alteration are very clearly given.

Griff Farm (South of). Intrusive in Lower Silurian Shales.

A bluish- to brownish-grey crystalline rock containing specks of pyrites.

Under the microscope this is seen to be composed of crystals of labradorite and hornblende with a considerable amount of serpentine or a pale greenish substance which appears to be serpentine, and which occasionally occurs in small spherical or fan-like fibrous aggregates. There is also some calcite present, the rock effervescing briskly when touched with acid. It is a diorite.

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[1] See also T. H. Waller, Geol. Mag. 1866, p. 235. The Quartzite.

[2] See also J. J. H. Teall, Hornblende-Bearing Rocks, Geol. Mag. 1886, p. 351.

Chilvers Coton Railway-Cutting. A sheet three inches thick in .Lower Silurian Shales.

A greenish-grey or greyish-green rock of very fine texture, profusely speckled with dark-green crystals and containing much pyrites, crystallized in cubes.

Under the microscope this rock appears to consist of pale green serpentinous matter with interlacing sheaf-like aggregates of small slender acicular crystals, having frequently rather ragged boundaries. These crystals often undergo extinction at an angle of 19° from their longest diameter, and it may be assumed from this and from their pleochroism that they are hornblende. There appears to be very little felspathic matter in this rock. There are, however, a few imperfectly formed crystals of labradorite present. The serpentine may possibly be pseudomorphous after olivine, but the sections are very irregular in form, and there is no positive evidence upon this point. A few grains of augite are visible in this section, as well as irregularly-shaped patches of pyrites.

Chilvers Coton Railway-Cutting. Intrusive in Lower Silurian Shales.

A medium-grained crystalline rock of a pinkish-grey, closely speckled with dull green crystals and containing minute specks of pyrites.

Under the microscope it is seen to consist of triclinic felspar, hornblende, rather sparsely distributed grains of magnetite and pyrites, a very few minute crystals of apatite and some isotropic or nearly isotropic matter, which may represent an interstitial glass. The felspar appears as a rule to be labradorite. The rock is essentially a diorite.

Chilvers Coton Railway-Cutting. Intrusive in Lower Silurian Shales. Three feet from top of dyke.

A greenish-grey crystalline rock of fine texture, containing numerous minute specks of pyrites.

The constituents of this rock appear under the microscope to be triclinic felspar (labradorite), serpentine, apatite pyrites, and a little unaltered augite. The serpentine, which is very plentiful in the section, may be an alteration product after augite or after some other mineral, but upon this point the section affords no trustworthy evidence. The rock is probably some kind of andesite.

Midland Quarry, Nuneaton Station. Intrusive in Hartshill Quartzite.

A very fine-grained purplish-grey rock showing under a pocket-lens a small quantity of a light-green mineral resembling epidote and minute octahedra of magnetite. The specimen attracts the magnetic needle.

Under the microscope the constituents are seen to be triclinic felspar, augite, olivine, magnetite, and serpentine, the latter substance being probably pseudomorphous after olivine. A few fan-like or divergent groups of capillary crystals occur here and there in the section. They undergo extinction approximately parallel to the longest axes of the minute rods, and are probably epidote. The magnetite occurs in irregularly-shaped grains and in well-developed octahedra. A little hornblende may be present, but the evidence for this is not satisfactory. The rock is a diabase.

Stockingford Cutting, Midland Railway (E. of bridge). Intrusive in Lower Silurian Shales.

A very fine-grained, greenish-grey crystalline rock, containing small spots and very numerous minute specks of pyrites. The rock effervesces freely when touched with acid.

Under the microscope it is seen to consist of triclinic felspar (labradorite), serpentine often in pseudomorphs after olivine, hornblende, pyrites, calcite, and specks of a yellowish white substance, either kaolin or leucoxene, but probably the former. It is difficult to say whether this rock is to be regarded as a basalt or a diorite. The occurrence of olivine in dioritic rocks from this neighbourhood has already been noticed by Mr. S. Allport.[1]

Midland Railway, Stockingford Cutting, Nuneaton. Upper surface of dyke intrusive in Lower Silurian Shales.

A very fine-grained greenish-grey or drab-coloured crystalline rock, showing numerous minute specks of pyrites.

Under the microscope the constituents appear to be chiefly triclinic felspar, serpentine pseudomorphous after hornblende, a very little unaltered hornblende and a considerable quantity of pyrites, some of which occurs in triangular sections which give angles of approximately 110° (the angle formed by the edges of an octahedron). It therefore seems probable that the pyrites in this case is pseudomorphous after magnetite, and this appears the more likely since no magnetite is visible in the section, although the rock is one in which this mineral is generally present. So far as I am aware, pseudomorphs of pyrites after magnetite are of very unusual occurrence, but instances are quoted by Delesse.[2] The rock is a diorite.

Oldbury Reservoir. Very thick sheet intrusive in Lower Silurian Shales.

A greenish-grey crystalline rock, spotted with numerous dark-green or blackish crystals of hornblende. It also shows many specks of pyrites and the joint planes are coated with calc-spar.

Under the microscope the rock is seen to be composed of triclinic felspar, crystals of hornblende, larger than those seen in the rocks already described, and exhibiting the interrupted crystallization, sometimes termed ophitic, a considerable quantity of kaolin, specks of pyrites and also a little calcite. The rock is a diorite.

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[1] Quart. Journ. Geol. Soc. vol. xxxv. p. 639.

[2] Récherches sur les Pseudomorphoses, Tableau II. p. 52, Annales des Mines, t. xvi. 1859.

Dosthill (intrusive in Lower Silurian Shales).

A fine-grained greenish- to greyish-brown crystalline rock.

Under the microscope it is seen to consist of more or less imperfectly developed lath-shaped crystals of triclinic felspar, which, from the extinction angles of some of them, appear to be labradorite, octahedra and irregularly-shaped grains of magnetite, apatite and pseudomorphs of serpentine, apparently after hornblende, since the angles of some of these pseudomorphs correspond with the angle of the oblique rhombic prism in hornblende.

The rock may be regarded as an altered diorite.

APPENDIX II.

IV.—ON THE NEW SPECIES *OLENUS NUNEATONENSIS* AND *OBOLELLA GRANULATA*, FROM THE LOWER SILURIAN ('CAMBRIAN,' LAPWORTH), NEAR NUNEATON.

By GEORGE SHARMAN, Esq.

Olenus Nuneatonensis, S., sp. nov.

Locality.—West end of the Midland Railway cutting, between Nuneaton and Stockingford.

Several fragmentary specimens of this Trilobite, differing in size, yet exhibiting similar characters, have been collected from this locality. The most perfect, although one of the smallest, is best fitted for description.

The length of this specimen is three-eighths of an inch, and the head, or cephalic-shield, is rather more than one-third of the entire length. The glabella is very convex, slightly narrowing in front, but inflated and bending over the frontal margin. The neck-furrow is distinct, the basal groove runs across the glabella, and there appear to be two short indistinct furrows on each side. There are eleven to thirteen body-rings, the pleuræ of the 5th, 6th, and 7th bearing short spines, and the 8th possessing a produced spine half as long as the specimen itself, and projecting beyond the end of the tail. The four terminal segments of the body also have spines, lessening in length towards the tail. The tail is short, the axis showing it to be composed of three, or perhaps more segments; it narrows posteriorly, and is subtruncate, being indented as in *O. micrurus*.

This species is distinguished from *O. micrurus* by the more lengthened spines from the posterior angles of the cheeks, and the possession of those attached to the pleuræ of the lower segments of the body, the nearer approach and bending over of the glabella towards the anterior margin, the continuance of the basal groove across the glabella, and in the anterior portion of the body being more parallel-sided. The character of the tail appears in all respects to agree with that of *O. micrurus*.

It is distinguished from *O. bisulcatus*, Phil., by the absence of the mesial spine on the cephalic-shield.

The marked difference in the size of these Trilobites (as before mentioned) would undoubtedly suggest the probable presence of two species, yet after a careful examination of the larger specimens, which are unfortunately only fragments, the characters appear to be the same as those of the smaller ones just described, and therefore, until better specimens can be found, they are regarded as the same species.

Obolella granulata, S., sp. nov.

Locality.—Lane on the south side of Purley Park, near Atherstone.

Only two specimens have been collected by the Survey, and although somewhat imperfect, yet they exhibit characters separating them from previously described species.

On first viewing the specimens, the form and general appearance of *Siphonotreta* is strongly suggested, but the structure and ornamentation is found on closer examination to differ considerably from it; radiating ribs apparently underneath the general surface of the shell are clearly seen extending from the beak towards the margin, and these commencing and terminating irregularly, none however quite reaching from the beak to the margin of the shell.

The surface of the whole shell is minutely granulated, giving an appearance of very fine concentric wavy lines. The umbonal region not being quite perfect prevents any definite determination of the genus, but provisionally it is placed with *Obolella*.

V.—ON THE FFYNNON BEUNO AND CAE GWYN CAVES.

By HENRY HICKS, M.D., F.R.S., F.G.S.

THE best reply that I can make to Prof. Hughes' remarks, in the GEOLOGICAL MAGAZINE for November, on the Ffynnon Beuno Caves, is to publish the substance of the report presented to the British Association, especially as an opportunity will be given to those interested in the inquiry to examine the section during the further explorations to be carried on, probably in the month of June next year. Some of his statements—especially as regards the position of the fence, which is entirely at the opposite end of the cavern to that at which the flint flake was found, also as to the position of the flake, and the nature of the deposits overlying it—are so entirely misleading, that I can only account for such statements being made by the fact that Prof. Hughes did not visit the section, though strongly urged by me to do so, until it had been almost entirely covered over, and work for the time suspended, and by his hasty survey of the surrounding conditions.[1] That such experienced geologists as Prof. Boyd Dawkins, Mr. Morton, Mr. De Rance, Mr. Strahan, Mr. Shone, and Dr. Stolterfoth, should, after careful examination, have been perfectly satisfied that the Glacial deposits overlying the flake and Mammalian remains were in an entirely undisturbed condition, and that they agreed with the views of the members of the Committee (Mr. Luxmoore, Mr. P. P. Pennant, Mr. E. Morgan, and myself), who were almost daily present at the explorations, is, I think, ample proof that Prof. Hughes' deductions are entirely at variance with the facts.

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[1] It is surprising that Prof. Hughes did not recognize that the accumulation against the upper side of the old fence, "until there is now a drop of eight feet to the level of the ground on the lower side of the fence," mentioned by him as of such great importance, is merely material conveyed there during the explorations. Before work was commenced, the space between the old fence and the entrance was almost bare rock, and there was nothing resting against the fence. No wonder then that he should have come to the conclusion that this was remanié drift, and that he thought he recognized on some of the stones "traces of agricultural implements as well as true Glacial striæ." The remarkable thing is that he should not have recognized the difference between this very recently mixed material near the old entrance and the stratified deposits in the shaft at the other end of the cavern. The term "Clwydian," if it is at all advisable to give local names to drift, is a most unsuitable name for the *undisturbed* glacial deposits on the higher levels, and should be confined to those at and about St. Asaph, which are at a low level near the centre of the Vale of Clwyd, and

Report of the Committee, consisting of Professor T. McK. Hughes, M.A., F.G.S., H. Hicks, M.D., F.R.S., H. Woodward, LL.D., F.R.S., E. B. Luxmoore, M.A., P. P. Pennant, M.A., and Edwin Morgan, appointed for the purpose of exploring the Caves of North Wales.—Drawn up by Dr. H. Hicks, Secretary.

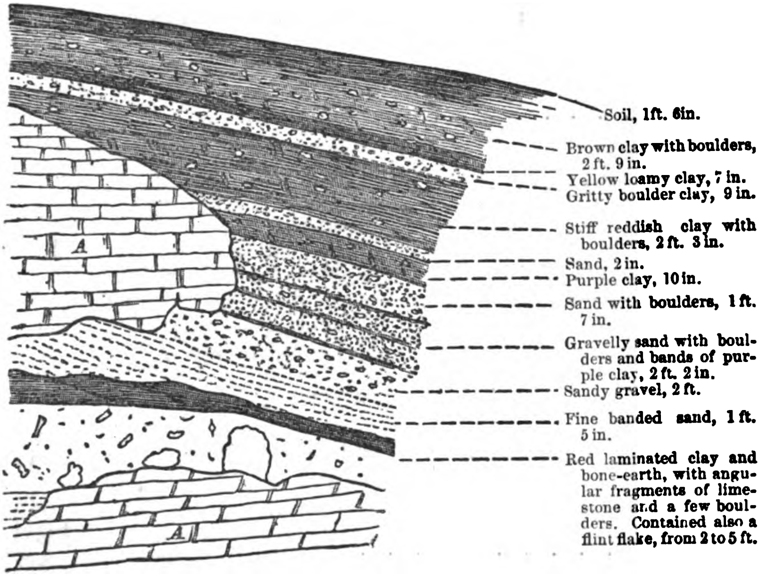
The explorations conducted by the Committee have been confined to the caverns of Ffynnon Beuno and Cae Gwyn, in the Vale of Clwyd. These caverns had been explored in preceding years by Dr. H. Hicks and Mr. E. B. Luxmoore, some of the results being given in a paper communicated to the Geological Section of the Association in 1885, but more fully in a paper in the Quart. Journ. Geol. Soc. February, 1886.

between the important rivers Elwy and Clwyd. This is in the main part remanié, and as such the term "Clwydian" might be applied to it. The undisturbed glacial deposits, stratified marine sands, and the overlying clay, containing large boulders of local rocks and northern erratics, found at Cae Gwyn and at so many other points in the neighbourhood at a high level far away from, and beyond the influence of any important river, ought not, on any account, to be termed "Clwydian." The true glacial deposits which overlaid the Mammalian remains and flint flake at the entrance to Cae Gwyn Cave belong to a much earlier phase than the Clwydian drift about St. Asaph and at other low levels in the valley, bordering the great rivers. The Cefn and Plas Heaton Caves, mentioned by Prof. Hughes, are also at a very much lower level than the Ffynnon Beuno Caves, and are so near to the rivers that I do not think the evidence furnished by them can be quoted as of much value either way, though it is well known that many have contended that the evidence in the Cefn Cave was distinctly in favour of its having been occupied by the animals before the great submergence in the Glacial period. The evidence cited by Mr. Strahan, in his recent excellent Memoir, as having been obtained in sinking shafts at the Talargoch mines, conclusively proves that Mammalian remains occur there in the very lowest glacial deposits. It is the great height at which the Ffynnon Beuno Caves occur, the impossibility of their having been disturbed by fresh water, the evidence of their having been occupied as dens before the great submergence, of the stalagmite floor having been broken up by marine action, of the bones having been cased in marine sand, and of the caverns having afterwards been completely buried under marine sand and an overlying undoubted boulder clay, containing many large ice-scratched boulders, that make the evidence found in them and in their immediate neighbourhood of such great value. The facts in my opinion are conclusive, and they cannot be altered by any amount of special pleading. Prof. Hughes' argument about the absence of flint and other foreign rocks in what he calls the oldest deposit, is founded on negative evidence derived from a limited examination. Mr. Strahan, the latest authority on the drift of this area, says (Geol. Survey Mem. 1885), "The passage from the one Boulder clay into the other is gradual, nor can it be said that one under or overlies the other. They were no doubt formed contemporaneously, differing only in the source of supply of material." Sir C. Lyell in speaking of the Moel Tryfaen beds says ("Student's Elements," 1871), "In the lowest beds of the drift were large heavy boulders of far-transported rocks, glacially polished and scratched on more than one side." Prof. Hughes' palæontological argument is found on examination to be almost equally inapplicable, as a very large proportion of the animals occur in the Norfolk forest-bed, which is acknowledged by all to be of pre-Glacial age. The fact that some others have not been found in the caverns probably indicates that they did not migrate into this area.

Among the remains discovered in these two caverns up to the commencement of the work this year there were over eighty jaws belonging to various animals, and more than 1300 loose teeth, including about 400 Rhinoceros, 15 Mammoth, 180 Hyæna, and 500 Horse teeth. Other bones and fragments of bones occurred also in very great abundance. Several flint implements, including flakes, scrapers, and lance-heads, were found in association with the bones. The most important evidence, however, obtained in previous researches was that bearing on the physical changes to which the area must have been subjected since the caverns were occupied by the animals. During the excavations it became clear that the bones had been greatly disturbed by water action, that the stalagmite floor, in parts more than a foot in thickness, and massive stalactites had also been broken and thrown about in all positions, and that these had been covered afterwards by clays and sand containing foreign pebbles. This seemed to prove that the caverns, now 400 feet above Ordnance datum, must have been submerged subsequently to their occupation by the animals and by Man. One of the principal objects, therefore, which the Committee had in view this year was to critically examine those portions of the caverns not previously explored, so as to endeavour to arrive at the true cause of the peculiar conditions observed. Work was commenced at the end of May, and carried on during the whole of June and parts of July and August.

CAE GWYN CAVE.

When the explorations were suspended last year, it was supposed that we had just reached a chamber of considerable size, but after a few days' work this year it was found that what appeared to be a chamber was a gradual widening of the cavern towards a covered entrance. The position of this entrance greatly surprised us, as hitherto we had believed that we were gradually getting further into the limestone hill. The rise in the field at this point, however, proved to be composed of a considerable thickness of glacial deposits heaped up against a limestone cliff. As the materials covering the bone-earth within and at the entrance were chiefly sands and gravels, it was found necessary to suspend operations in that direction and to ask the landlord (E. Morgan, Esq.) for permission to open a shaft directly over this entrance from the field above. As this necessitated the removal of a considerable surface of land, and caused some damage to the field, the Committee feel that their special thanks are due to Mr. Morgan for his kindness in so readily acceding to their application. This shaft, as at first opened, was about nine feet across at the surface and over five feet at the bottom. It was subsequently widened at the bottom in consequence of some falls and the lower part, excepting at one point, had to be carefully faced with timber. The upper part is now much widened and sloped. The shaft was about twenty feet in depth, and the deposits as shown in Fig. 1 were made out in it. These were carefully measured by Mr. C. E. de Rance, F.G.S., Mr. Luxmoore, and the writer during the prosecution of the work. Below the soil, for about eight feet, a tolerably stiff boulder clay, containing many ice-scratched boulders and narrow bands and pockets of sand, was found. Below this there were about seven feet of gravel and sand, with here and there bands of red clay, having also many ice-scratched boulders. The next deposit met with was a laminated brown clay, and under this was found the bone-earth, a brown, sandy clay with small pebbles and with angular fragments of limestone, stalagmite, and stalactites.


Soil, 1ft. 6in.
Brown clay with boulders, 2 ft. 9 in.
Yellow loamy clay, 7 in.
Gritty boulder clay, 9 in.
Stiff reddish clay with boulders, 2 ft. 3 in.
Sand, 2 in.
Purple clay, 10 in.
Sand with boulders, 1 ft. 7 in.
Gravelly sand with boulders and bands of purple clay, 2 ft. 2 in.
Sandy gravel, 2 ft.
Fine banded sand, 1 ft. 5 in.
Red laminated clay and bone-earth, with angular fragments of limestone and a few boulders. Contained also a flint flake, from 2 to 5 ft.
A
A

A. Carboniferous Limestone. ◊ Position of the flint flake.

Fig. 1. Section at New Entrance to Cae Gwyn Cave.

On June 28, in the presence of Mr. G. H. Morton, F.G.S., of Liverpool, and the writer, a small but well-worked flint flake was dug up from the bone-earth on the south side of the entrance. Its position was about eighteen inches below the lowest bed of sand. Several teeth of Hyæna and Reindeer, as well as fragments of bone, were also found at the same place, and at other points in the shaft teeth of Rhinoceros and a fragment of a Mammoth's tooth. One Rhinoceros tooth was found at the extreme point examined, about six feet beyond and directly in front of the entrance. It seems clear that the contents of the cavern must have been washed out by marine action during the great submergence in mid-Glacial time, and that they were afterwards covered by marine sands and by an upper-boulder clay, identical in character with that found at many points in the Vale of Clwyd and in other places on the North Wales coast. Figs. 2 and 3 explain the order of the deposits as found within the cavern.

Fig. 3 was taken at a distance of about sixteen feet from the entrance at the shaft, and Fig. 2 just within that entrance. The order in that portion of the cavern examined this year accorded in the main with that found during the previous researches, but within the entrance there was a greater thickness of sand, less of the laminated clay, and more bone-earth than in the other parts of the cavern. The bone-earth seems to diminish in thickness rather rapidly outwards under the glacial deposits, but it was found as far out as the excavations have been made. Here the bone-earth rests directly on the limestone floor, with no local gravel between, as in the cavern.

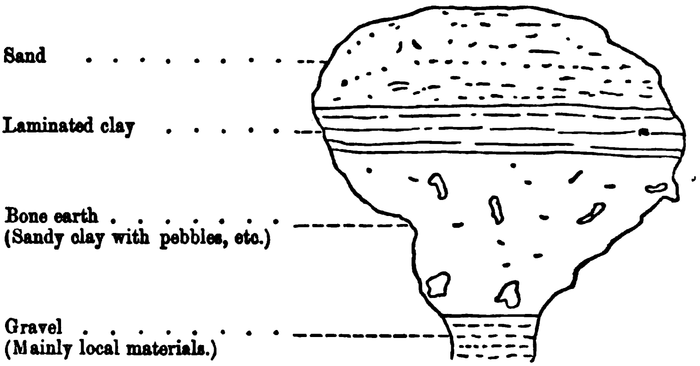


Fig. 2. Section in Cae Gwyn Cave, near the New Entrance.

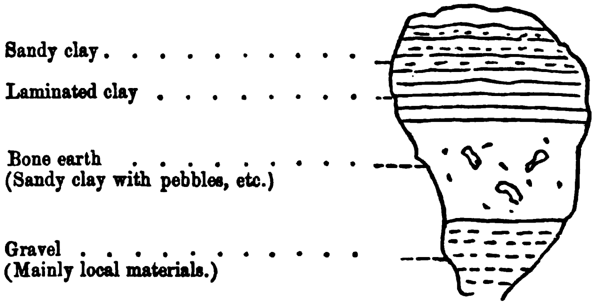


Fig. 3. Section in Cae Gwyn Cave, about 16 feet from the New Entrance.

It would be interesting to know how far the cave earth extends under the glacial deposits, but this could only be ascertained by making a deep cutting through the terrace of glacial deposits, which extends for a considerable distance in a westerly direction. The glacial deposits here are undoubtedly in an entirely undisturbed condition, and are full of smooth and well-scratched boulders, many of them being of considerable size. Among the boulders found are granites, gneiss, quartzites, flint, felsites, diorites, volcanic ash, Silurian rocks, and limestone. Silurian rocks are most abundant. It is clear that we have here rocks from northern sources, along with those from the Welsh hills, and the manner in which the limestone at the entrance to the cavern in the shaft is smoothed from the north would indicate that to be the main direction of the flow. The marine sands and gravels which rest immediately on the bone-earth are probably of the age of the Moel Tryfaen and other high-level sands, and the overlying clay with large boulders and intercalated sands may be considered of the age of the so-called upper-boulder clay of the area. The latter must evidently have been deposited by coast-ice. Whether the caverns were occupied in pre- or only in inter-glacial times it is difficult to decide, but it is certain that they were frequented by Pleistocene animals and by Man before the characteristic glacial deposits of this area were accumulated. The local gravel found in the caverns, underlying the bone-earth, must have been washed in by streams at an earlier period, probably before the excavation of the rocky floor of the valley to its present depth. From the glacial period up to the present time excavation has taken place only in the glacial deposits, which must have filled the valley up to a level considerably above the entrances to the caverns. The characteristic red boulder clay with erratic blocks from northern sources is found in this area to a height of about 500 feet, and sands and gravels in the mountains to the S.E. to an elevation of about 1400 feet. The natural conclusion therefore is that the caverns were occupied by an early Pleistocene fauna and by Man anterior to the great submergence indicated by the high-level marine sands, and therefore also before the deposition of the so-called great upper-boulder clay of this area. As there is no evidence against such a view, it may even be legitimately assumed that the ossiferous remains and the flint implements are of an earlier date than any glacial deposits found in this area.

Ffynnon Beuno Cave.

This cavern, which yielded the greatest number of bones in the previous researches, has now been cleared out in all those parts where the deposits appeared to have been undisturbed by Man. A considerable addition to the number of bones and teeth has been made this year, but no new forms have to be added to those already mentioned.

The animal remains found in the caves, as defined by Mr. W. Davies, F.G.S., of the British Museum, comprise teeth and bones of eleven genera and sixteen species, as shown by the annexed list:—

Lion (*Felis leo*, var. *spelæa*).
Wild Cat (*F. catus ferus*).
Spotted Hyæna (*H. crocuta*, var. *spelæa*).
Wolf (*Canis lupus*).
Fox (*C. vulpes*).
Bear (*Ursus*, sp.).
Badger (*Meles taxus*).
Wild Boar (*Sus scrofa*).
Bovine (*Bos ? Bison ?*).
Great Irish Deer (*Cervus giganteus*).
Red Deer (*Cervus elaphus*).
Roebuck (*C. capreolus*).
Reindeer (*C. tarandus*).
Horse (*Equus caballus*).
Woolly Rhinoceros (*R. tichorhinus*).
Mammoth (*Elephas primigenius*).

REPORTS AND PROCEEDINGS.

I.—November 3, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.

The President noticed the presentation, on the part of Dr. Hector, of a preliminary report of the late eruptions in New Zealand, and stated that Dr. Hector hoped shortly to communicate a paper to the Society on the subject; papers had also been sent or promised on the same subject by other New Zealand geologists, and it was hoped that before long the Society would be in possession of very full accounts of these remarkable volcanic outbursts.

The following communications were read:—

1. "On the Skull and Dentition of a Triassic Saurian, *Galesaurus planiceps*, Ow." By Sir Richard Owen, K.C.B., F.R.S., F.G.S., etc.

The author referred to a fossil skull from the Triassic sandstone of South Africa, which combined dental characters resembling those of a carnivorous Mammal with the cranial structure of a Saurian. The structure was described and figured in Owen's 'Catalogue of the Fossil Reptilia of South Africa,' under the generic title of *Galesaurus*, as belonging to a distinct suborder of REPTILIA, termed *Theriodontia*.

The characters of the skull and teeth of the original specimen of *Galesaurus* have been brought to light by further development.

In both the type specimen and that lately received the reptilian nature of the fossil is indicated by the single occipital condyle and other features. The chief difference from a mature male of a placental or marsupial carnivore is the evidence of a primordial "gullet-tract." Further details as to the structure of the skull were given, more especially with reference to the orbits and nasals. The palatal region repeats the same general characters as in previously described Theriodonts. The angle of the jaw is not produced, as in the Crocodile, beyond the articular element. In general shape and bony strength the mandible of *Galesaurus* resembles that of a mammal.

The dentition is so much better preserved in the new specimen than in the type Galesaur as to call for description, and illustration. In four of the upper molars the entire crown is preserved; it shows less length and greater breadth than appears in the previous restoration, is moderately curved externally, and triangular; the base is flanked by a short cusp before and behind, and the corresponding margins are finely crenulate, as in the molars of *Cynodracon*. The incisors are eight in number in both upper and lower jaws, four in each premaxillary, opposed or partially interlocking with the same number in each mandibular ramus; they have longish, slender, simple-pointed crowns. The canines, one on each side of both upper and lower jaws, have the same laniariform shape and size of crown as in the original fossil. In the right maxillary bone the long deeply planted root is exposed; the corresponding part of the lower canine is similarly exposed in the left mandibular ramus. No trace of successional teeth, as in ordinary Saurians, has been found.

Both Crocodiles and Alligators have two or more teeth of canine proportions; but the author shows how they differ from those of mammalian carnivores and *Galesaurus*. A similar character and disposition of destructive canines is shown by the fossil jaws of the Oolitic great extinct carnivorous Saurians, e.g. *Megalosaurus*. In the Triassic Labyrinthodonts the destructive and prehensile laniaries would by position rank as incisors rather than canines. In existing Lizards the dental series has more uniformity, and the cement-clad roots contract bony union with the jaw-bone. In *Galesaurus* the teeth, besides being distinguished, as in Mammals, by their differential characters, are implanted freely in sockets, the cold-blooded character being chiefly manifested in the greater number of teeth following the canines, and in their want of distinction.

Lastly, the author remarked on the earlier reptilian character shown by the Oolitic Mammal *Amphitherium*, and also by the existing Australian *Myrmecobius*. He speculates on the degree of resemblance manifested by the teeth of the old Triassic Reptile of South Africa with the exceptional characters of some of the low Australian forms of Mammals.

2. "The Cetacea of the Suffolk Crag." By R. Lydekker, Esq., B.A., F.G.S., etc.

This paper commenced with notices of previous contributions to the subject by Sir R. Owen, Prof. Ray Lankester, Prof. Huxley, and Prof. Flower. In the preparation of a catalogue of the specimens in the British Museum, the author had had occasion to examine the collection of Cetacea from the Crag, not only in that Museum, but also in the Museum of Practical Geology, that of the Royal College of Surgeons, and in the Ipswich Museum, besides visiting the collections at Brussels. In consequence several additions to the fauna and also numerous emendations of specific names were noticed in the paper now laid before the Society. Prof. Ray Lankester's views as to the Diestian affinities of the English-Crag Cetacea were confirmed by this comparison.

Detailed notes on the specimens examined and the species identified were given. The following list of the species believed to be represented in the various collections mentioned was given at the conclusion of the paper:—

BALÆNIDÆ.

Balæna affinis, Owen.
,, *primigenia*, van Beneden.
,, *insignis* (van Beneden).
,, *balænopsis* (van Beneden).
Megaptera affinis, van Beneden.
,, *similis* (van Beneden).
,, *minutus* (van Beneden).
Balænoptera definita (Owen).
,, *Goropi*, van Beneden.
Balænoptera borealina, van Beneden.
,, *emarginata* (Owen).
Cetotherium Brialmonti (van Beneden).
,, *dubium* (van Beneden).
,, *Hupschi* (van Beneden).
,, *brevifrons* (van Beneden).
Herpetocetus scaldiensis (van Beneden).

PHYSETERIDÆ.

Eucetus amblyodon, du Bus.
Homocetus Villersi, du Bus.
Balænodon physaloides, Owen.
Physodon grandis (du Bus).
,, *fusiformis?* (du Bus).
Hoplocetus crassidens, Gervais.
,, *borgehoutensis*, Gervais.
,, *crassidens?* Gervais.
Hyperoodon, sp.
Choneziphius planirostris (Cuvier).
Choneziphius planus (Owen).
,, *Packardi*, Lankester.
Mesoplodon longirostris (Cuvier).
,, *tenuirostris* (Owen).
,, *gibbus* (Owen).
,, *angustus* (Owen).
,, *angulatus* (Owen).
,, *compressus* (Huxley).
Floweri, Canham MS.

Squalodontidæ.

Squalodon antverpiensis, van Beneden.

Delphinidæ.

Orca citoniensis, Capellini.
Globicephalus uncidens (Lankester).
Delphinoid genus, *non det.*

3. "On a Jaw of *Hyotherium* from the Pliocene of India." By R. Lydekker, Esq., B.A., F.G.S., etc.

Colonel Watson, the Political Resident in Kattiawar, had recently sent to the author a fragment of a left maxilla with the three true molars from Perim Island, in the Gulf of Cambay. The specimen belonged to *Hyotherium*, and apparently to an undescribed species, the differences between which and the several forms previously known from various European and Asiatic beds, were pointed out. The author also called attention to the peculiar association of types found in the beds of Perim Island, and to the affinities of the genus *Hyotherium* with the recent *Sus* and *Dicotyles* on the one hand, and with the Upper Eocene *Chæropotamus* on the other.

CORRESPONDENCE.

THE FACETTED BLOCKS FROM THE PUNJAB SALT RANGE.

Sir,—Had I been aware that the abstract of my remarks "On a Smoothed and Striated Boulder from a Pretertiary Deposit in the Punjab Salt Range" would appear in the Geological Magazine, together with Mr. Wynne's notes on another facetted fragment from the same bed, I would have asked permission to add a few observations.

The great difficulty in accounting for the origin of these facetted blocks is that whilst the smoothed surfaces are in every respect similar to those on stones worn by glacial action, no fragments from moraines, from boulder-clay, or from other glacial deposits are known to exhibit the peculiar facetting characteristic of the present specimens. I have heard of something similar, but have not seen an example. Other geologists who have a wide experience of smoothed and striated boulders are equally puzzled.

At the British Association meeting two suggestions were offered as to the cause of the markings—the first was soil cap action; this, however, could not have produced the facets, nor, unless it acted in two or more directions at the same time, could it have caused the striation. The other suggestion was wind and sand action, by which similarly facetted blocks are said to have been produced in Australia. My objections to this view are that wind and sand action never, so far as I have seen, produce plane surfaces, that the striation (or rather grooving) on wind-worn surfaces is of a different character, and that the wind-worn fragments sent from New Zealand by Mr. Enys, and figured in the Quart. Journ. Geol. Soc. for 1878 (xxxiv. p. 86), as well as some described in the American Naturalist (occurring, I think, in Maine), have no resemblance to the Punjab specimens. Further and very cogent arguments are supplied by Mr. Oldham in a paper which I trust will shortly be published in this Magazine.

Before concluding, may I point out that felspar-porphyry on p. 494 is a misprint for felsite-porphyry.

Nov. 8th, 1886.

W. T. Blanford.

THE FOLIATION OF THE LIZARD GABBRO.

Sir,—Students of petrology will, I am sure, feel indebted to my friend Mr. Teall, no less for his valuable paper on the Lizard Gabbro than for the admirable Plate with which it is illustrated. He has stated very clearly the reasons in favour of ascribing the peculiar rock-structure, there described and depicted, directly or indirectly to mechanical influences. In this it is quite possible he may be right. But, inasmuch as there seems to me some danger at the present time of overestimating the part played by mechanical agencies in producing the crystalline schists—a part which hitherto undoubtedly has been much underestimated—a danger in short of supposing that *a* truth is "*the* truth, the whole truth, and nothing but the truth," I venture to put a few words on record, not so much by way of protest or criticism, as for the purpose of showing that in Mr. Teall's proposed solution of this puzzle there are difficulties on which he does not dwell, so that it ought at present to be regarded as an hypothesis on its probation, and should not be quoted (as I feel sure it would otherwise be) as an undoubted fact. My remarks, be it understood, must be regarded as directed, not against the general principle, of which this Lizard gabbro would be a particular case, but against the application of the principle to this case.

The difficulties which I feel may be thus stated. If the foliation of the Lizard gabbro is the result of earth-movements acting on the rock after it became solid, these movements, having resulted in effects of an exceptional character, should have been of exceptional importance—that is to say, the whole district should bear the impress of the same earth-movement that has foliated the gabbro. Mr. Teall states indeed: "that the Lizard district has been profoundly affected by earth movements is apparent on every hand." Speaking for myself, I should prefer to read 'considerably' for 'profoundly,' so far as regards the earth-movements to which we could ascribe the foliation of the gabbro. I am well acquainted with three large separate areas of country which have been 'profoundly affected by earth-movements' since their rocks became solid, and I do not find a parallel to them in the Lizard, except perhaps at the extreme south and near the great boundary fault on the north. There are undoubtedly numerous dislocations (as I have pointed out in one of my papers on the district); there are endless wrenches, slips and nips; but there are few signs of a great compression such as may often be traced through whole regions of crystalline rock almost as surely (when the key to it is once found) as a slaty cleavage in one of sedimentary rock. This foliation of the Lizzard Gabbro, as Mr. Teall truly says, comes in and disappears, even in the thin veins, in apparently the most arbitrary manner. This of course is perplexing in any theory of its origin. I only quote it to show that our difficulties are so far not diminished by the new one. Again, the foliation often occurs where the neighbouring rocks show little or no signs of material disturbance. I do not say that the contrary is not sometimes the case, but near the Balk (or Pen Voose), and to the north of Karakclews, and at Coverack this is the case. Serpentine is a decidedly brittle rock. Any one who knows the Alps is familiar with its pressure-modifications. Yet the serpentine at all these three places, as a rule, is singularly perfect in its structure, free from all indications of serious mechanical disturbance. There are, I am well aware, serpentines at the Lizard which might be quoted as evidencing 'pressure-structure,' but, as it happens, these do not occur at any one of the three localities where the foliated gabbros exist. At all three the serpentines are perfectly normal in their characters. But it might be asserted that, at the epoch of the pressure, the serpentine existed as a peridotite, and this very possibly would be true; still I think I know what is the effect of pressure on a peridotite, and could conjecture what the results would be when it was converted into a serpentine, and of these also I find no signs at the above-named places.

But it may be argued that this foliation in the gabbro is the result not so much of a general compression of the district, as of local strains, thrusting, and shearing in the gabbro-mass itself, due to local disturbances; that it is a structure resulting from *faulting* rather than from *folding*—from dislocation-strains rather than compression-thrusts. So far as the minor cases at the Balk and Coverack are concerned, this explanation would seem feasible, but it is difficult to apply it to such an enormous mass as that of Karakclews, where the differentiation and parallel ordering of the minerals have an extraordinary development. Moreover, as Mr. Teall justly says, this mass sends out veins into the neighbouring serpentine, and that rock to the north has been repeatedly pierced by small gabbro veins, so that we cannot suppose the main mass to have been thrust far away from its original position.

There are then, as it seems to me, some serious difficulties in applying the theory of pressure-foliation to the Lizard gabbros, if it be assumed that the structure was produced in a solid rock. Mr. Teall's solution of the difficulty *may* be the right one, but it is always well to look at all sides of a question. A new answer to one of Nature's greater riddles is often rather a first approximation to the truth, than the actual truth, and stands in need of subsequent modification. As at present advised, I am disposed to think this the case in regard to the Lizard gabbro, though further study may remove my difficulties. Still I think we shall do well to proceed cautiously in regard to this new hypothesis of pressure-metamorphism. It has come to many, like myself, almost as a revelation, pouring a flood of light upon a number of dark enigmas; but for all that we must not allow it to dazzle our eyes. In this, as in so many other things, reason should go hand in hand with faith. T. G. BONNEY.

NECROLOGY.—We have to record with deep regret the recent losses by death of Dr. H. Abich, F.M.G.S. (Vienna); Mr. George Busk, F.R.S., F.G.S.; Rev. W. Downes, B.A., F.G.S.; the Earl of Enniskillen, D.C.L., F.R.S., F.G.S.; Mr. Caleb Evans, F.G.S.; and Prof. F. Guthrie, F.R.S., F.G.S.

ERRATUM.—GEOL. MAG. November Number, p. 492, line 10, delete "difficult."

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